Literature Review of Genetic Algorithm in Power System

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Abstract

The utilization of genetic algorithm (GA) in tackling engineering problems has been a major issue arousing the curiosity of researcher and practitioner system and engineering research, operation research and management sciences in last few years. The various improvement occurs in it year by year, and researches has been done over genetic algorithm to improve its limitation and to process well. In view of this, this paper present a state-of-the-art survey of application of GA technique in engineering with focus on system power optimization using GA in last few years to understand what changes has been done till now and its improvement of various papers that are searched. The scope of the paper is centered between the years 2000-2016.

Keywords: Optimal Power Flow, Hybrid Optimization, Genetic Algorithm, FACTS

I. INTRODUCTION

The vast areas of application of GA optimization technique in tackling problem that cannot be handled using the conventional methods and stochastic search are the focal areas of keen interest for consideration in this paper.

GA is type of evolutionary algorithm (EA) that is found useful in so many engineering applications which includes numerical and combinatorial optimization problem, filter design as in the field of signal processing, designing of communication networks, semiconductor layout and spacecraft and so on. It is founded on the bases of natural biological evaluation process which is used to mimic nature in searching for optimal solution of a specific problem.

In the description of GA, the definition of chromosome and fitness functions is of paramount importance. Chromosomes are abstract representation of candidate solution. The fitness function is used in quantifying the desirability of the solution, which is closely correlated with the objective of the algorithm or optimization process. The fitness level is used in evaluating candidate solution, that is, the values being generated characterize the solutions.

In GA, the most promising search space areas are being explored through the utilization of probabilistic rule, hence minimizing the risks of convergence to local minima. This is achieved by simultaneously considering many points in the search space and favoring the mating of the fitter individuals.

GA is a robust search algorithm that enables the quick location of high quality solution areas in a complex and large Search space. Among the numerous advantages of GA is its Capability of considering individual population with each population representing a solution to the problem which gives its edge over other search algorithm. The fundamental principal of GA includes selection, reproduction, population solution, encoding and decoding, fitness function evaluation and convergence.

This paper presents a concise detailed survey of applications of GA technique in engineering with focus on system power optimization. Finally, conclusions are presented.

II. A CONCISE REVIEW OF APPLICATIONS OF GA TECHNIQUES IN POWER SYSTEM

In 2000, A development of an improved genetic algorithm expansion planning (GEP) problem was concerned with a highly constrained nonlinear dynamic optimization problem that can only be fully solved by complete enumeration, a process which was computationally impossible in a real-world GEP problem. In this paper, an improved genetic algorithm incorporation a stochastic crossover technique and an artificial initial population scheme was developed to provide a faster search mechanism. The main advantage of the IGA approach is that the “curse of dimensionality” and a local optimal trap inherent in mathematical programming methods can be simultaneously overcome. The IGA approach was applied to two test systems, one with 15 existing power plants, 5 types of candidate plants and a 14-year planning period, and the other, a practical long-term system with a 24-year planning period [1].
In 2001, Hosseini, Rahnavard and Kharrati focused on the use of advanced techniques in genetic algorithm for solving power system stabilization control problems. Dynamic stability analysis of power system was investigated considering proportional Integral Derivative power system stabilizer for modern power system. The proportional-integral-derivative power system stabilizer (PID-PSS) had been proposed for the enhancement of dynamic stability of modern power system. Gain setting of PID-PSS had been optimized using advanced genetic algorithm by presentation of a new cost function in time domain. The proposed method was implemented on a case study power system and simulation results reveal that GA method gives much better dynamic performances as compared to that of LQR and FUZZY PID-PSS [2].

In 2002, Bakirtzis and Zoumas proposed an enhanced genetic algorithm (EGA) for the solution of the optimal power flow (OPF) with both continuous and discrete control variables. The continuous control variables modeled are unit active power outputs and generator-bus voltage magnitudes, while the discrete ones are transformer-tap settings and switchable shunt devices. A number of functional operation constraints, such as branch flow limits, load bus voltage magnitude limits, and generator reactive capabilities, was included as penalties in the GA fitness function (FF). Advanced and problem-specific operators was introduced in order to enhance the algorithm’s efficiency and accuracy. Numerical results on two test system was presented and compared with results of other approaches [3].

A general framework for the optimization of experimental design in functional magnetic resonance imaging (fMRI) using GA was proposed by Wager and Nichols in 2003. A method for choosing design factors and a particular succession of events in functional magnetic resonance imaging (fMRI) was presented. GA was utilized to maximize statistical power and psychological validity by choosing a design factors and a particular succession of events in functional magnetic resonance imaging. Also, the merits of using GA structure for optimization were also investigated viz: the capability of operating with any type of model, permitting for very precise parameterization of experimental states, including nonstandard trail models and experimentally examined scanner autocorrelation, and its flexibility concerning fitness criteria. The results obtained shows that the GA optimization generated designs perform better than the random designs. However, it takes more processing time [4].

The solution of optimal power flow problem of large distribution systems via a simple genetic algorithm presented by Bouktir, Slimani, Belkacemi in 2004. The objective is to minimize the fuel cost and keep the power outputs of generators, bus voltages, shunt capacitors/reactors and transformers tap-setting in their secure limits. To save an important CPU time, the constraints are to be decomposing in active constraints and reactive ones. The active constraints are the parameters whose enter directly in the cost function and the reactive constraints are infecting the cost function indirectly. With this approach, only the active constraints are taken to calculate the optimal solution set. And the reactive constraints are taking in an efficient load flow by recalculate active power of the slack bus. The developed system was then tested and validated on the IEEE30-bus system. Solutions obtained with the developed Genetic Algorithm Optimal Power Flow program has shown to be almost as fast as the solutions given by a conventional language. Our GAOPF appears to be faster than other published GAOPF methods [5].

In 2005, Shahirinia, Tafreshi presented an optimized design of stand-alone multi sources hybrid power system includes sources like, wind farm, photovoltaic array, diesel generator and battery bank based on an evolutionary algorithm. In this work, the battery bank had been used to cover the emergency loads energy. For this approach, economic aspects such as interest rate, inflation, capital recovery factor, sinking found factor had been expressed for each power sources, and then an objective function with aim to minimizing of all system costs, had been clarified. A genetic algorithm approach was employed to obtain the best cost value of hybrid power system calculates the electrification costs (capital cost, replacement costs, operation and maintenance cost and fuel cost) over a period of 20 years for two different cases [6].

High power and performance requirement which are critical design issues in wireless system was addressed by Suleiman and Arslan in 2006. The paper proposed the utilization of GA for the optimization of word length for both data and coefficients in real time pipelined fast Fourier transform (FFT) processor design. It was shows that different domain ranges impacts on the speed of the search, its value and the turbulence as the GA converges towards a given solution. However, this approach has a better performance with lesser error at their outputs and can be used for most digital signal processing tasks that need real time operation [7].

Hybrid optimization technique to analyze meta-material based electrically small antennas was proposed by Erentok and Ziolkowski in 2007. A hybrid of GA-Matlab based model was used in the optimization of the far-field radiation behaviours of a system. The system is a model of an ideal radiating system made up of an electrically small electric dipole antenna put in an electrically small multi-layered meta-material shell system. This presented a multi-parameter electro-magnetic setback of optimization requiring a vigorous method that will generate global maxima. GA optimization results were employed to get the upper and lower solution space bounds that were needed to compute the maximum total radiated power obtained from the MATLAB optimization package, thereby optimizing the total radiated power of this system applying the technique of GA-MATLAB mix which gives a better performance. However, it is computationally complex [8].

A novel technique for the parameters optimization of the Unified Power Quality Conditioner (UPQC) using Genetic Algorithm (GA) was presented by Benachaaiba, Abdelkhalek, Dib and Haidsa in 2007. The work aims at enhancing the behaviours of UPQC compared to frequency variations. A new GA based method was offered intending to make UPQC resolve most power problems taking advantages of series and shunt active power filters to balance the deformation of both source voltages and load currents while taking into account the complex structure that utilizes several elements working as one. It was shown that the GA optimized parameter has a better performance and more efficient when compared to the classical method. However, it is computationally complex [9].
A modified GA based optimization design of fuzzy governor power system stabilizer (FGPSS) for hydro-generator unit was proposed by Wang et al. in 2008. The paper attempts to address the shortcomings of the Exciter Power System Stabilizer (IPSS) which includes the trouble of choosing a right installation place and the complexity of balancing parameters of multi-machine system. An amended single-point crossover method known as Head-and-Tail Alternate Crossover (HTAC) was proposed. It was revealed that the modified algorithm is faster and more accurate when compared to the Error-and-Trial method and conventional GA. Also, the FGPSS optimized with modified GA improved the stability of hydroelectricity scheme although, it requires more processing time and is computationally complex [10].

Panda and Padhy (2008) presented a comparison of the uses and performances of particle swarm optimization (PSO) and genetic algorithm (GA) optimization methods for Thyristor Controlled Series Compensator (TCSC)-based controller design. The work aims at improving the power system stability. A design optimization problem of the FACTS-based controller was formulated; both the PSO and GA optimization techniques were used to search for optimal controller parameters. The eigenvalue analysis and the nonlinear simulation results demonstrated their capability to offer good damping of low frequency oscillations and advance immensely the voltage profile of the system. The results obtained shows that both PSO and GA algorithms were useful in optimizing the parameters of a FACTS-based controller. The GA technique was faster in terms of computational time. The GA computational time increases linearly with the number of generations, while the PSO computational time increases just about exponentially with the number of generations [11].

Several optimization methods that can be utilized in solving the Short-term hydrothermal coordination (STHTC) problems were proposed Farhat and Hawary in 2009. An appraisal and a style-based categorization majority of the research papers on the topic were also examined. GA was used to work out the hydro sub-problem in view of the water balance as well as the effects of net head and water travel time delays using a realistic system to test the method and balance its performance to a dynamic programming approach. The results showed GA has better performance with good solution value and efficiency [12].

An Improved Catastrophic Genetic Algorithm (ICGA) for optimal reactive power optimization was proposed by Ouyang Sen in 2010. The research was on reactive power optimization (RPO), which is a nonlinear planning problem with the qualities of definite, multiple variables and constraints which has a large influence on secure and economic function ability of power systems. The aims are to decrease network losses, advance voltage level and sustain the power system running under usual conditions. The work strives at working out the problems in usual optimization methods that can limit their applications in RPO. Genetic-Catastrophic Algorithm (GCA) is offered. In GCA, a catastrophic operator (new operator) is suggested to recover the population diversity when premature happens just like in GA. Adaptive genetic algorithm (AGA) is also initiated in this paper in order to advance the GA’ s convergent pace and searching potential. In AGA crossover and mutation probabilities are varied depending on the number of generations and the fitness value, respectively. The suggested ICGA was applied to reactive power optimization of power system. Results of the IEEE 14-bus system show that ICGA can carry out global search with a fast convergence rate and a mark of preferable convergence stability. It was confirmed to be proficient and realistic during the reactive power optimization [13].

In 2011, Nasri and Gashaoui worked on the efficiency of the FLC-GAO technique to solve the optimal power flow (OPF) combinatorial problem utilizing two algorithm. The Fuzzy Logic Controller (FLC) algorithm was used for critical nodal detection while GA Optimization (GAO) is used for optimal capacitor sizing. Decline in active power transmission, decreasing power losses, and increasing of the drop voltage are the key setbacks caused by reactive power flow issues. The proposed method was able to address these key issues. This method was observed and assessed on the standard IEEE 57-bus, the results confirmed improvements in the power loss minimization, voltage profile, stability and efficiency [14].

Spur gear optimization using GA was proposed by Mohan and Seshaiyah in 2012. The objectives of the spur gear design were to minimize centre distance; minimize weight of the meshing gear set and minimize tooth deflection. Furthermore, the problems associated with the usual design process which gives out a single result for manufacturing was addressed. The design results, evaluation, comparison and analysis show that GA methods gave more number of solutions out of which the best solution is chosen by fitness value, while traditional method gave only one or two optimal solutions [15].

Instruction scheduling for low power using GA was done by Hai and Binh in 2013. The work is aimed at optimizing power consumption in embedded system engineering with emphasis on embedded systems that use battery power source thereby reducing power cost of processor(s) and prolonging the lifetime of the system. In designing the GA for the scheduling problem, Hai and Binh employed the technique introduced by C. Moon et al. using analytically two open source simulation tools namely, Simple Scalar Tools Set and Simple Power algorithms. The simulation results showed that GA is a superior technique for the problem of scheduling for low power, with a large search space and an intricate optimal solution thus confirming efficiency of the work [16].

In 2013, The Optimization of OFDM systems using GA in FLGA was proposed by Venkatachalam and Manigandan. The work aimed at avoiding the complications and challenges of the intricate prohibitive task of optimal subcarrier, bit and power allocation in practical communication systems. A proposed solution dividing the problem into two by first finding the optimal allocation of subcarriers to users, and then finding the optimal allocation of bit and transmit power for each user was put forward. The main disadvantage of the algorithms earlier proposed is their high computational complexity. In addition, this subcarrier and power allocation to each user at base-station maximize the user data rates, subject to constraints on total power and bit error rate. The projected genetic search aids quick convergence and can take care of large allocations of subcarriers to users with no performance degradation. The GA technique was utilized because of its suitability for optimum resource allocation [17].
In 2014, Ghandari and Madhu presented Optimal Allocation Of SVC For Reactive Power Loss Minimization In Powed Systems by using genetic algorithm. With the help of the FACTS controllers, it is possible to reduce real & reactive power losses in the power system. Their location, type & rating have influence on system performance. Location & type chosen should be proper & rating must be optimal for economical operation of the power system. This work presented a new approach to find the optimal ration of FACTS controllers by using Genetic Algorithm (GA) & conventional Newton Raphson power flow method. Among various FACTS controllers, Static VAR Compensator (SVC) is considered in this work. Our objective is to minimize the reactive power loss in the sytem by Placing optimum rating of the SVC. It has used reactive power loss minimazation as objective function to find the optimal rating of SVC. The proposed algorithm was an effective & practical method in this direction. To verify the effectiveness of proposed algorithm, studies were carried out on IEEE 9 bus & IEEE 30 bus systems, with different loading conditions. Different loading conditions considered were normal loading condition, 80% loading condition, 90% loading condition & 120% loading condition. Each test system, with same loading condition was examined [18].

In 2015, Padmavathi, Sahu and Jayalaxmi presented a novel stochastic hybrid differential evolutionary algorithm technique to find the optimal location of Flexible Alternation Current Transmission System (FACTS) devices with minimum cost of installation and to improve power system security an is compared with Genitic Algorithm (GA). Differential Evolution (DE) algorithm and shows better performance but greedy in space searching. Particle Swarm Optimization (PSO) converged quickly and but stuck in local optima. A novel heuristic method based on Genetic algorithm also used to find optimal location of FACTS devices to enhance the power system security and no absolute assurance of global optimum. In this paper hybrid differential evolutionary algorithm (DEPSO) was introduced to eliminate the problems of DE and PSO and solve the power system security problem with greater accuracy and compared with Genetic Algorithm. The proposed algorithm minimized the security index, loss and the installation cost of FACTS devices in the transmission network. Security index indicated the overload level of the transmission lines. Three types of FACTS devices, Static Var Compensator (SVC), Thyristor Controlled Series Compensator (TCSC) and Unified Power Flow Controller (UPFC) was verified by standard IEEE 14 bus network [19].

Om and shukla focused at providing a solution to optimal power flow problem in power systems by using Genetic Algorithm approach in 2016. The proposed approach fund the optimal setting of OPF control variables which include generator active output, generator bus voltages, transformer tap-setting and shunt devices with the objective function of minimizing the fuel cost. The proposed Genetic Algorithm technique was modeled to be flexible for implementation to any power systems with the given system line, bus data, generator fuel cost parameter and forecasted load demand. Proposed genetic algorithm technique have been analyzed and tested on the standard benchmark IEEE 30-bus system. Results obtained after applying both optimization techniques on American Electric IEEE 30-bus system with the same control variable maximum & minimum limits and system data have been compared and analyzed. Proposed method efficiently optimized and solved the optimal power flow problem with high efficiency and wide flexibility for implementation and analysis on different power networks [20].

### III. Conclusions

This paper presented a review of various application of GA in power optimization related problems only. The need for the optimization of parameters or factors in order to achieve specific goals, improve performance and efficiency of system power was examined. In addition to the various GA optimization methods that have been used by researchers for power optimization was an enhanced hybrid GA technique that can be used for power optimization in different fields of engineering.

### References


