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Application of Firefly Algorithm based Neural Network Controller

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Abstract*: The Firefly Algorithm is comparison of new optimize procedure based on PSO as tautness. The paper presents the competence and forcefulness of the Firefly algorithm as the optimize concept for a proportional–integral–derivative organizer under various loading conditions. The proposed PID controller is attempt to designed and implemented to frequency-control of a two area interconnected systems. The hidden layer formation is not personalized, as the interest lies only on the reckoning of the weights of the system. In sequence to obtain a practicable report, the weights of the neural network are computational or optimized by minimizing function cost or error. A Firefly Algorithm is an efficient but uncomplicated meta-heuristic optimization technique inspired by expected motion of fireflies towards more light, is used for the preparation of neural network. The simulation report view that the calculation competence of training progression using Firefly Optimization performance with Load frequency control. A study of the output report of the system PID controller and FA based neural network controllers are made for 1% change in load in area 1 and it is found that the proposed controllers ensures a better steady state response of the systems.

Keywords: Neural Network (NN), Firefly Algorithm (FA), Optimization Technique, Proportional-Integral-Derivative (PID) Controller, Load Frequency Controls (LFC).

I. INTRODUCTION

The Optimization has been an energetic area of research for present decades. As many real-world optimization difficulties become more multifaceted, better optimization algorithms remained needed [1-5]. In all optimization complications the goal is to find the smallest or maximum of the impartial function. Over the last years, many arithmetical optimization techniques have been working to improve the competence of the back propagation algorithm counting the conjugate gradient parentage However, one limitation of this technique, which is a gradient-descent technique, is that it requires a differentiable neuron handover function. Also, as neural networks engender multipart error superficial with numerous local minimal, the BPNN spill into local modicums instead of a global minimal. Evolutionary multiplication is often utility to train the weightiness and restrictions of neural networks [6, 7]. The drawbacks of gradient-based methods are improved by erudition algorithms. These processes include worldwide search presentation such as artificial bee association algorithm [8], particle crowd optimization (PSO) [9], discrepancy evolution (DE) [10], ant association back propagation algorithm [11], hereditary algorithms (HA) [12] and Cuckoo search (CS) [13] etc. In this broadside, a new nature stimulated meta-heuristic procedure, named Firefly Algorithm (FA) is presented for optimization problematic preparation of ANN. The firefly algorithm [14] [15] is grounded on the behavior of arrangements of fireflies towards more light. Here, the conjunction behavior and presentation of the projected ANN application using FA is analyzed consuming proposed Firefly Back Promulgation Algorithm (FBPA).

II. NEURAL NETWORK

This paper uses reproduction neural network and gets continuous gradation index values of the examples, then it turn the gradation values of experiential example into the enduring real degree amount and then gets the danger values. It is knowledgeable by a presentation that the technique is greater to traditional indicator model, so as to improve the result of conservative estimation.

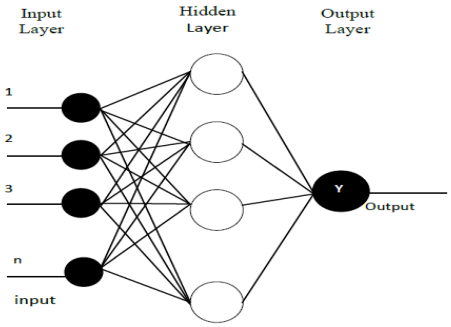

Figure 1 NN Architecture

Neural Network (NN) derives its derivation from the working of humanoid brain. NN is an information dispensation model which consists of manifold single processing units (neurons), these neurons are massively corresponding in nature which achieves highly complex calculations. The individual goal of NN is to create a processer grasp somewhat so that complex would change to a particular dataset. NN, family people learn by example. These capabilities make NN useful for decoration acceptance, speech acknowledgment or else arrangement problem. The structure of the neural network has three variant layers. The system input layer is a set of hidden units, which accept the parts of input mouth vectors. The participation sections (neurons) are fully associated to the secreted with the hidden layers. The secreted layers are also entirely associated to the output part. It gives the output reply of neural to the process add in to the input section.

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The material specific to a nn is proliferated layer-by-layer from contribution layer to output layer finished (none) one or else hidden layers.
The optimal position and size of the distributed production section have been strong-minded in line to reduce the system power losing without infringe the system no-nonsense constriction using the projected algorithm strictly establish. Moreover, the optimal distributed producer position and minimum size for accomplish a certain particular power losing are strong-minded utilize the projected method.

III. ADAPTATION OF FIREFLY ALGORITHM

The Firefly Algorithm is one of optimization method. The blinking brightness of fireflies is a remarkable vision in the daylight sky in the steamy and contented areas. The flashes pattern is commonly different from each firefly classes. The blinking brightness is fashioned by a bioluminescence procedure and the exact purposes of such gesticulating methods are still perplexing.

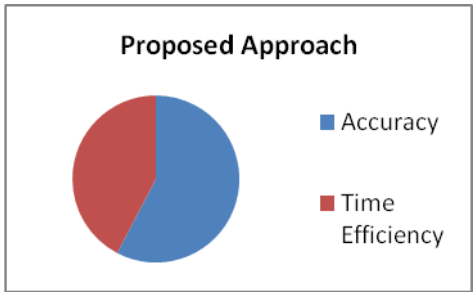

Figure 2. Accuracy and Time Efficiency of Firefly Algorithm

Obviously fireflies gives illumination by attract in the direction of light. The intensity of light is verbalized in such a method that it is directly similar with the un prejudiced role to be enhanced, which construct it conceivable to create new booster algorithms, acknowledged as Firefly Algorithm.
One newly industrialized nature-inflame meta heuristics process is the firefly algorithm (FA), which is inflamed by the blinking features and comportment of humid fireflies. This nature tenth used meta experiential process precisely notice both world and indigenous optimum.
FA follows rules:
(i) Due to the asexual of fireflies being unisex, one firefly can be concerned by further fireflies irrespective of femininity;
(ii) Attraction and illumination are corresponding to each further, so the reduced optimistic fireflies will be pinched to additional intense. As afar intensifications, the charmful diminutions and determine that around is no brighter one than a specific firefly, it will move erratically.
(iii) A firefly illumination is unrushed by the country side of the unprejudiced process.
The factors W1, W2,…..Wn are weights to regulate the strong point of input vectors I = [I1,I2,…..In]T. Each input is bourgeoned by the connected of the neuron constructionITW which can be given as subsequent formula. The optimistic weights stimulate and the undesirable weights constrain the output.

$$I=IT.W=I1W1+I2W2+……..+InWn= Iini=1 \quad (1)$$

The nodes intermission threshold ϕ is the greatness offset. It affects the initiation of output O as:

$$O = f(I) = f\{ IiWini=1 - \phi k\} \quad (2)$$

For Arrangement task, ANN provides to be supervised for the complexes to be able to compose the target input production mapping. For exercise purpose a set of example statistics are feed to the network and joining weights, which is also called concise heaviness, are acclimate by using a knowledge algorithm. The impartial of a neural network order is to give a production due few input indications. Before the training of the neural network, the system is prepared to evasions characters, and all the productivities (possible responses of the system) have the same likelihood. While the system is trained, the masses that define the joining between notes adapted the value, and contingent on the two layers of input and hidden standards, the order can be also altered. That suggests that it is possible to optimize the neural networks adapting the construction of the solution and modifying the way that the masses are intended. Here, FA method has been used for the exercise of NN. For m amount of exercise data the shaped error can be assumed as

$$E= (t_i-o_i)^2mi=1 \quad (3)$$

Where t is the board output and o is the intended production from exercise data.

Firefly Algorithm Steps:

Step-1: Create starting population of fireflies X as.

$X = \{w_1, w_2,\ldots w_n\}$

Step-2: Calculate the illumination of each firefly by using detached function $f(w_i)$ as

$B= \{B1, B2\ldots.Bn\} = \{f(w_1), f(w_2)\ldots f(w_n)\}$.

Step-3: Set light preoccupation constant γ.

Step-4: While (t ≤ max iteration)

For i=1 to n

For j=1 to i

If ($I_j > I_i$)

Move firefly i to firefly j by using eq. (6).

End if

Attractiveness varies with detachment r via exp (−γr2).

Estimate new fireflies and modernize illumination by using eq. (3).

End for

End for

t = t+1

End while

Step-5: Rank fireflies rendering to their suitability and find the best one.

Step-6: If discontinuing criteria is touched, then go to step-7.

Else go to step-4.

Setp-7: Stop.

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IV. LOAD FREQUENCY CONTROL WITH FA CONTROLLER

A. Load Frequency Control in Power System

In present study, influence coordination with vicinity is recognized. In every thermal power are the proprietor system based of neural network with fire-fly algorithm (FA) for solving load frequency control is simulated in the MATLAB where this copy of the system is revealed in result and discussion. The regularity frequency bias are B1 and B_2 ; area be in change of errors are AOE_1 and AOE_2 ; control input of generation from the organizer are U_1 and U_2 ; the administrator speed regulation are R_1 and R_2; the momentum director time invariable are TG_1 and TG_2 in sec; t time invariable are T_{T1} and T_{T2} in sec; the load demand are PD_1 and PD_2; incremental revolutionize in the tie line supremacy is P_{tie} in pu; the supremacy system expand are KPS_1 and KPS_2 ; the power classification time steady are TPS_1 and TPS_2 in sec; the tie-line bring into line coefficient is T_{12} and frequency divergence of the organization are: gains are K_{PS1} and K_{PS2} ; the authority system time unvarying are T_{PS1} and T_{PS2} in sec; the tie-line constant is T_{12} and frequency divergence of the arrangement are: H_1 and H_2 in Hz. Proportional-Integral-Derivative control is used as less important controller to diminish frequency errors and movement away in the tie-line power. PID control is the most frequently used controller for stable procedure of the coordination in power engineering. A PID controller with FA provides fast process and less straightens out time as well as pick up the stability of the system. The PID controller in s-domain is arranged by

$$TFPID = Kp+K_I/s+KDS \quad (4)$$

The two area organizes errors (AOE) which are the error contribution to the organizer are given by:

$$f_1(t)=AOE_1=B1H_1+Ptie_{12} \quad (5)$$

$$f_2(t)=AOE_2=B1H_2+ Ptie_{12} \quad (6)$$

$$\alpha_{12}=-1 \quad (7)$$

B.PID controller optimization

In this controller optimization of problem, the fireflies are utilised to represent the PID parameters – K_p, K_i and K_d. The error criterion of the controller is used as the integral time weighted squared error method

$$ITSE = \int_0^t t.ACE_1{}^2\, dt \quad (8)$$

V. RESULTS AND DISCUSSIONS

In general, the three constraints which are more offen in Fire fly Algorithm i) α : the randomisation restriction, ii) β : the pleasant appearance and iii) γ : the assimilation coefficient. The concentration of fireflies light is specified by:

$$I(r) = I_0 e^{-\gamma r} \quad (9)$$

The firefly magnetism occupation is given by:

$$\beta(r) = \beta_0 e^{-\gamma r^2} \quad (10)$$

The detachment stuck between any two fireflies i, j can be distinct as:

$$\gamma_{ij} = \|y_i - y_j\| = \sqrt{\prod_{k=1}^{d}(x_{i,k} - x_{j,k})^2} \quad (11)$$

With the help of matlab/simulink surroundings the suggest model of the arrangement under learn has been enhanced in and agenda is register for FA.

The proposed system training is much faster with FA based NN. The proposed system training is much faster with FA based NN. The simulation studies were performed with these controllers for a step load interference of 0.01pu MW in area-1 and the related frequency deviation and tie – line power divergence are obtained in figures 3 to 6. It is selection from the output responses improves the transient reaction of the system but also has minimized the settling time.

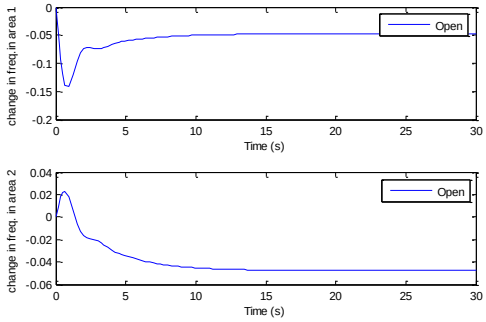

Figure 3 Open loop response of Area1 and area 2

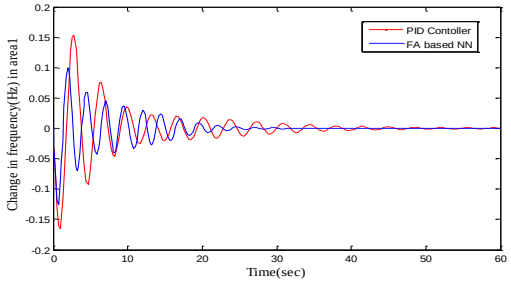

Figure 4 Frequency deviation area-1 for 1% step load disturbance in area 1

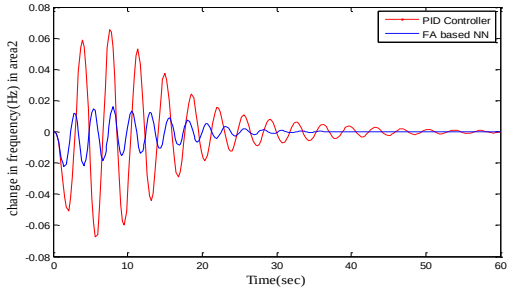

Figure 5 Frequency deviation area-2 for 1% step load disturbance in area 1

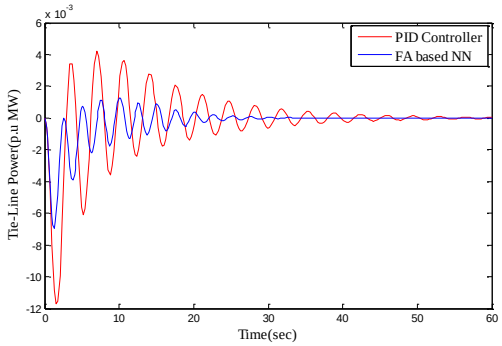

Figure- 6 Tie-line power deviation area-1&2 for 1% step load disturbance in area 1

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VI. CONCLUSION

Applications, using the FA and its amendment, carried out by many investigations are discussed and assessment to show how closes this procedure to present the most favorable solution. The FA based PID is obviously able to optimise the organizer through normalize the system reconnect with a negligible level of go beyond, straighten out time and fluctuation. From, the self-motivated system presentation it is clear that, FA based PID regulator with stands an assortment of circumstances of the consignment. Character activated meta-heuristic methods supply plagiaristic gratis solution to optimize combination complication. A new meta experiential search learning type, Firefly Algorithm is pragmatic to training BPNN to achieve speed meeting price and to minimize the training error. FA is applied to train the NN by exploiting the objective function definitely. However, the number of exercise data, populace of fireflies and repetition number must be satisfactorily high to obtain high correctness. The proposed FA based NN controller when implemented in a two area interconnected power system ensures an improved transitory response of the system than that of the output response get with PID Controller examination on the values of parameters like attraction and light intensity in better-quality version of firefly algorithm is to be investigated in the near future

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