IMPROVED ARTIFICIAL BEE COLONY(iABC)-WLAV TECHNIQUE IN POWER SYSTEM STATE ESTIMATION

(iABC)-Weighted least absolute value Compared with Particle Swarm Optimization Technique

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Abstract : The data of electrical network is normally at the control center and it uses certain protocols , the measured data have some uncertainties due the meter and communication error (noise) .
The aim of state estimation of state variables of power system by minimization the measurement error (noise) present at control center In this paper we discusses the application of an, improved Artificial Bee colony algorithm optimization (improved ABC)-weighted least absolute value method and its effectiveness over other AI optimization algorithm, Particle swarm optimization (PSO), is shown by comparing both the solution.
The true state variable values obtained by using Newton- Raphson (NR) algorithm.

I. INTRODUCTION

It is important for the energy management system (EMS) have real-time data and estimate values of loads, voltage, magnitude, generation and distributed power outputs etc. its only possible when all the state variables (voltage magnitudes and angle at each bus) of power system is known. For this traditional methods Newton and Gradient methods both suffers in handling inequality constraints, linear programming in oscillation and slow convergence , as the power system state variables are nonlinear variables , the Artificial intelligence (AI) algorithm considered as powerful tool, advantages they only required fitness function.

In this paper we discuss improved Artificial Bee colony (iABC) over other AI algorithms like Particle swarm optimization (PSO). The corruption of telemeter raw data measurements is simulated by introducing statistically a random error in the measurements obtained after running Newton-Raphson (NR) load flow algorithm. The solutions obtained from load flow (before introducing errors) are therefore considered as true solutions and used as benchmark solutions in evaluating the effectiveness of iABC solutions. Particle swarm optimization (PSO) is used in order to evaluate the iABC performance over this other AI algorithm. Since this work is not aimed at PSO and NR algorithms, the reader may refer respectively to references [13, 14] and [15] for information about these two algorithms. the approaches in solving state estimation problem, the weighted least square and IEEE 6 bus system, are used. Mat lab is used for simulation.

II. POWER SYSTEM STATE ESTIMATION

The general estimation consists of estimating the state vector *x* based on a set of Measurements *z* in the presence of an error *e*. A mathematical model describing the functional relations between *z*, *x* and *e* is described in equation (1) [2, 16, 17]. This model is expressed in the form of a set of nonlinear equations which relates the measurements *z* and the true state vector *x*.

$$Z_i = f_i(x) + e_i \ (or)\ e_i = Z_i - f_i(x) \tag{1}$$

Where, i=1, 2, 3, ...,m

z_i is the i^{th} measurement (measurement vector of dimension m);

$f_i(x)$ is the nonlinear function relating state variables with measurements. This is usually the power injections or power flow equations.

x is the state vector of dimension n .

e_i is the i^{th} measurement noise vector.

m : the number of measurements.

III. WLAV METHOD

The weighted least absolute value (WLAV) estimate for *x* can be found by minimizing the following objective function.

$$Min\ J(x) = \sum_{i=1}^{m} w_i |Z_i - f_i(x)| \quad (3)$$

All the parameters and variable in equation (3) are above defined. The nonlinear functions containing the state variable to be estimated, $f_i(x)$ are the active and reactive power injections, active and reactive power flows, whose equations can be found from. In this work, only some bus voltage magnitudes and power injections are assumed to be measured. The active and reactive power injections are given in polar form, as follows:

$$P_i = V_i \sum_{j=i}^{NB} V_j |Y_{ij}| cos(\delta_i - \delta_j - \theta_{ij}) \quad (4)$$

$$Q_i = V_i \sum_{j=i}^{NB} V_j |Y_{ij}| \sin(\delta_i - \delta_j - \theta_{ij}) \quad (5)$$

Where:
- P_i is the active power injection at bus i;
- Q_i is the reactive power injection at bus i;
- V_i and V_j are voltage magnitude at bus i and j
- δ_i and δ_j are voltage angles at bus i and j;
- Y_{ij} is the magnitude of bus-admittance element i, j and θ_{ij} its angle;
- *NB* is the number of bus.

Equations (4) and (5) represent different functions $f_i(x)$ in equations (1), (2) and (3) whose voltage magnitudes and angles are to be estimated for a given set of available measurements Z_i.

IV. Improved Artificial Bee Colony (IABC) Optimization Algorithm

We proposed a board to be used neighbourhood selection by inspiring bee colony optimization model. After employed bee phase, average fitness values obtained from employed bees is calculated as follows

$$Avg_t^{pop} = \frac{1}{N} \sum_{i=1}^{N} fit_i \quad (6)$$

Where, Avg_t^{pop} is average fitness values of employed bees population at iteration *t* and *N* is number of employed bees. The fitness values of employed bees are tested with Avg_t^{pop} and the solutions of employedbees, which are better than Avg_t^{pop}, are written to the board. Duration on the board of solutions is calculated by Equation (6).

$$D_i = K\ fit_i \quad (6)$$

Where, *K* is a positive constant number, fit_i is fitness value of i^{th} employed bees and D_i is waiting time on the board of the solution and waiting time of the solutions is proportional to fitness values of employed bees. As a result, neighbours for onlooker bees (x_k in Equation (10)) are no longer selected from the board

4.1 Initialization

ABC algorithm begins to work by random producing solution, initial solutions are produced for employed bee using equation (7)

$$x_{i,j} = x_j^{min} + \lambda(x_j^{max} - x_j^{min}), i = 1 \ldots N, j = 1 \ldots D \quad (7)$$

4.2 Employed Bee phase

In this step a new candidate solution are produced for each employed bees, the first solution of employed bee copied to new candidate solution ($v_i = x_i$).

After that , the only one parameter of solution is updated by using Equation (8)

$$v_{i,j} = x_{i,j} + \Phi(x_{i,j} - x_{k,j})\ i, k \epsilon \{1,2, \ldots, N\},\ \ j \epsilon \{1,2, \ldots, D\}\ and\ i \neq k \quad (8)$$

4.3 Onlooker Bee Phase

In ABC algorithm, each onlooker bee chooses an employed bee in order to improve its solution. This selection is done according to fitness values of employed bees by roulette wheel given in Equation (9).

$$p_i = \frac{fit_i}{\sum_{j=1}^{N} fit_j} \quad (9)$$

4.4 Scout bee Phase

The abandonment counters of all employed bees are tested with a number which is decided by designer (*limit*). The employed bee, which cannot improve self-solution until the abandonment counter reaches to the limit, becomes scout bee. Hereafter, a solution is produced for the scout bee by using Equation (7) and the abandonment counter is reset.

All these steps shows via flow chart below.

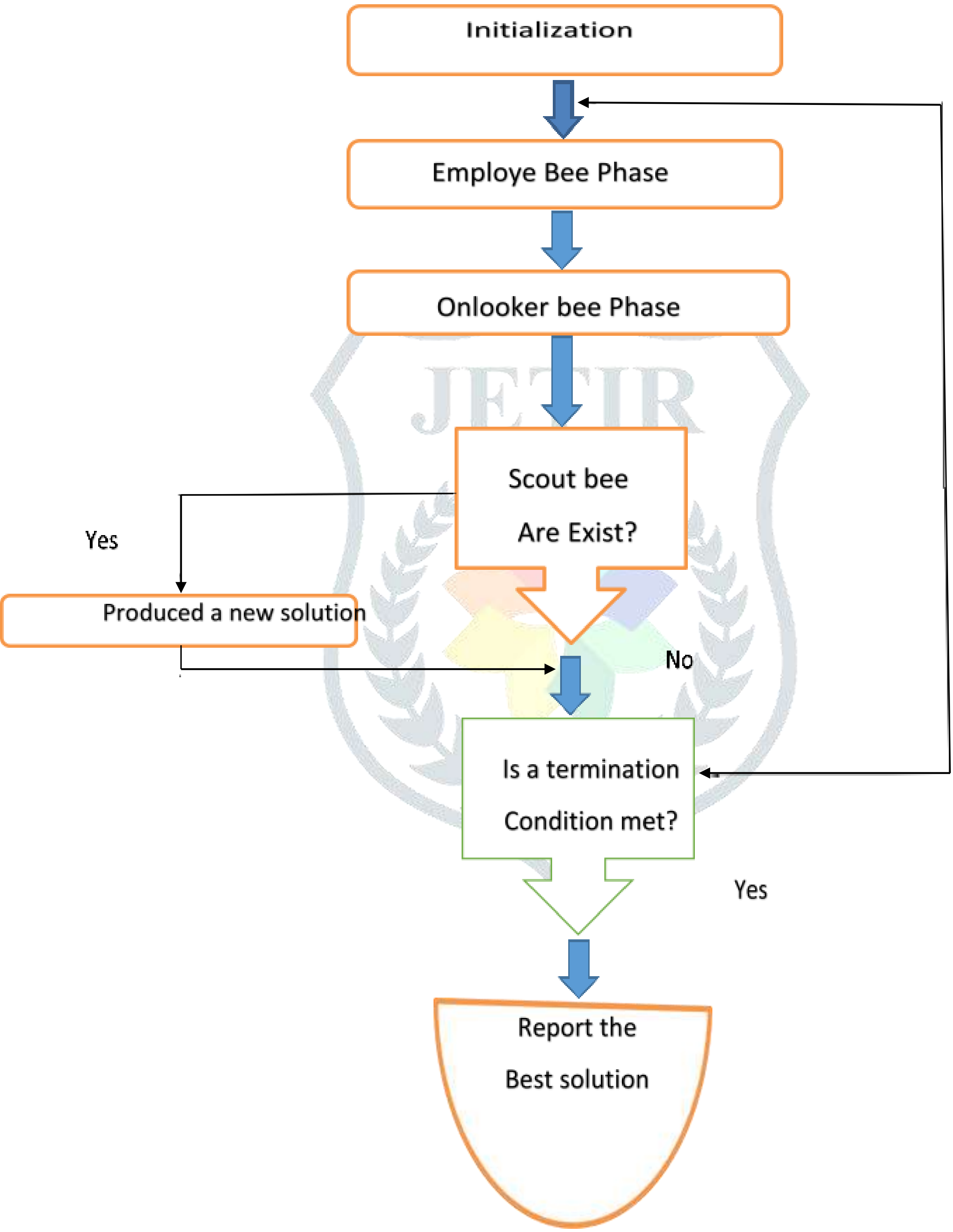
Initialization
Employe Bee Phase
Onlooker bee Phase
Scout bee
Are Exist?
Yes
Produced a new solution
No
Is a termination
Condition met?
Yes
Report the
Best solution

Fig.1 flowchart of improved ABC algorithm is given

IV. RESULTS AND DISCUSSION

As discussed in the literature, the analysis of Table-I reveals through both two formulations of the objective function (WLAV) that while using the same simulation basis (number of iterations and number of populations or population size), iABC algorithm allows lower computational time than PSO algorithm. For this particular case, iABC algorithm is about ten (10) times faster than PSO. Hence, using real-time processors, the computational time of iABC can be further reduced in such a way that this algorithm can be used for real-world applications to power system state estimation. A good convergence characteristic of iABC can also be seen through its objective functions which are lower compared to those achieved by GA algorithm.

When comparing the effectiveness of iABC algorithm to PSO algorithm in estimating the power system state variables With WLAV formulation, the analysis of Fig. 2 and Fig. 3 shows that iABC algorithm still more promising in estimating the voltage magnitudes compared to PSO algorithm. However, the results reveal a slight higher accuracy of PSO algorithm in estimating the voltage angles.

Table I - True, measured and estimated values (active and reactive power injections and voltages magnitudes and angle) by iABC – WLAV

Meter location	True value(p.u)			PSO-Measured value(p.u)			iABC-estimated value(p.u)			
	P	Q	V	P	Q	V	P	Q	V	Angle (deg)
Bus 1	0.9557	0.5212	1.0500	0.9639	0.5240	1.0883	0.9119	0.5226	1.0570	0
Bus 2	0.5000	0.2049	1.1000	0.5091	0.2103	1.1194	0.5119	0.2026	1.1103	-2.2101
Bus 3	-0.5500	-0.1300	-	-0.5487	-0.1204	-	-0.5507	-0.1323	0.9947	-12.1648
Bus 4	0.0000	0.0000	-	0.0091	0.0096	-	-0.0103	-0.0212	0.9250	-9.2728
Bus 5	-0.3000	-0.1800	-	-0.2937	-0.1784	-	-0.2620	-0.1783	0.9265	-10.7486
Bus 6	-0.5000	-0.0500	0.9077	-0.4990	-0.0403	0.9397	-0.4982	-0.0474	0.9195	-11.3256

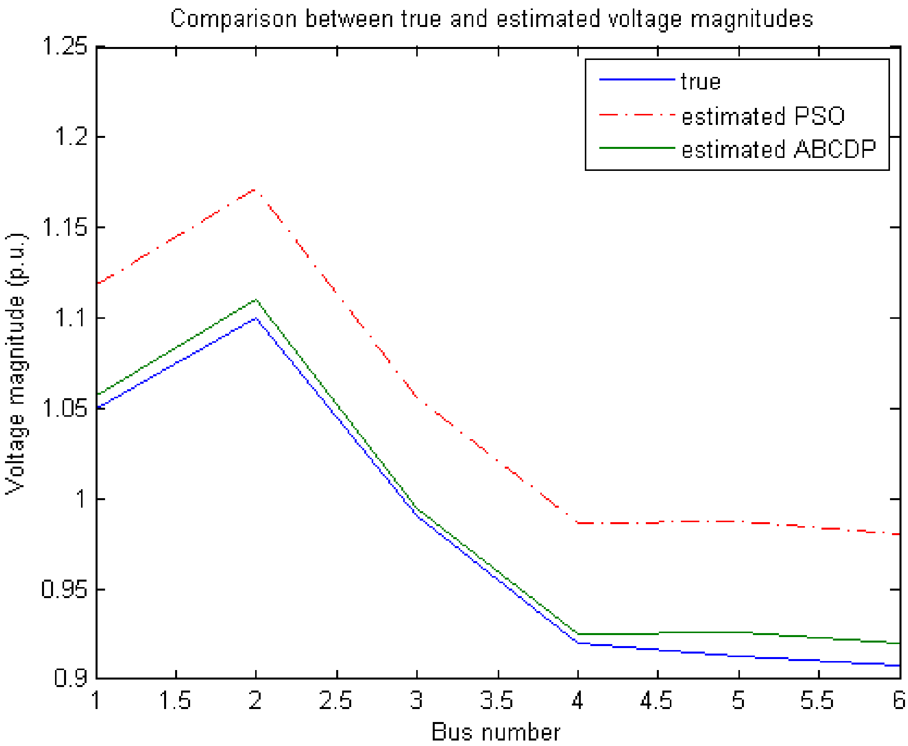

Figure-2. Comparison between estimated voltage magnitudes with PSO–WLAV and iABC–WLAV.

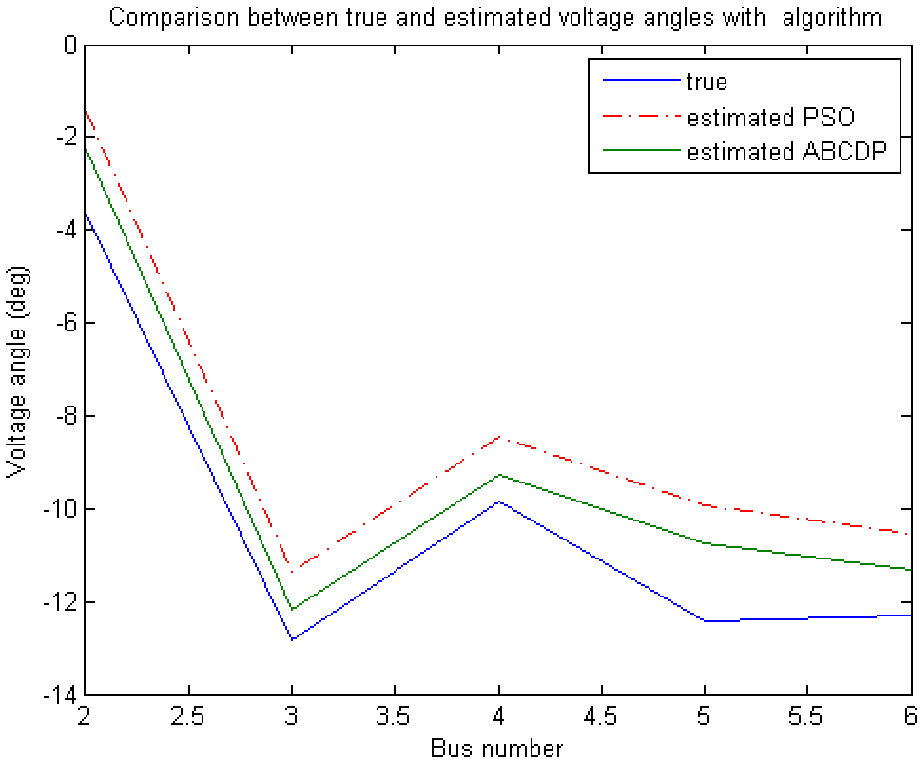

FIGURE-3. COMPARISON BETWEEN ESTIMATED VOLTAGE ANGLES WITH PSO–WLAV AND IABC–WLAV.

V. CONCLUSION

This paper discussed the application of Improved ABC (iABC) algorithm for power system state estimation. Newton-Raphson load flow algorithm has been used to generate the benchmark solutions taken as true values of the state variables to be estimated from the corrupted measurements available in the power system control center. Particle Swarm Optimization (PSO) has been used as a second artificial intelligent (AI) algorithm so as to evaluate the performance of iABC algorithm, using two formulations of the objective function. The weighted least absolute value (WLAV). The results have shown a higher accuracy with lower computational time for iABC-WLAV algorithm in estimating the state variables of the IEEE 6 bus test system compared to PSO algorithm. Taking advantages of iABC over classical optimization algorithms which are mainly based on gradient theory, and over other AI algorithms requiring higher computational time, the results revealed that iABC algorithm can be promising in the real-time application for power system state estimation since computers are becoming more faster.

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