# An Efficient Scheduling for Security Constraint Unit Commitment Problem Via Modified Genetic Algorithm Based on Multicellular Organisms Mechanisms

Ali Yazdandoost, Student Member, IEEE, Peyman Khazaei, Student Member, IEEE, Rahim Kamali Student Member, IEEE, Salar Saadatian, Student Member, IEEE

Abstract-Security Constraint Unit commitment (SCUC) is one of the significant challenges in operation of power grids which tries to regulate the status of the generation units (ON or OFF) and providing an efficient power dispatch within the grid. While many researches tried to address the SCUC challenges, it is a mixedinteger optimization problem that is difficult to reach global optimum. In this study, a novel modified genetic algorithm based on Multicellular Organisms Mechanisms (GAMOM) is developed to find an optimal solution for SCUC problem. The presentation of the GAMOM on the SCUC contain two sections, the GA and modified GAMOM sections. Hence, a set of population is considered for the SCUC problem. Next, an iterative process is used to obtain the greatest SCUC population. Indeed, the best population is selected so that the total operating cost is minimized and also all system and units' constraints are satisfied. The effectiveness of the proposed GAMOM algorithm is determined by the simulation studies which demonstrate the convergence speed. Finally, the proposed technique is compared with well-known existing approaches.

Keywords—Power operation, SCUC, modified GA, evolutionary method

## I. INTRODUCTION

SECURITY Constraint Unit commitment (SCUC) is considered as a decision-making problem in power system operation issues. Indeed, based on the possible SCUC results, the day-ahead generators status determine to satisfy the load demand [1]. The goal of the SCUC issue is to supply the needed energy while the cost is minimized and all constraints associated with the problem are satisfied [1-3]. Hence, the output of the SCUC problem is ON or OFF status of generation units and also their hourly generation amount. Therefore, the status of generation units and hourly economic dispatch are two concerns that should be determine simultaneously.

Numerous evolutionary and mathematical techniques were investigated for SCUC problem, such as, mathematical modeling based on mixed-integer programming (MIP) [4], or evolutionary modeling based on Lagrangian relaxation (LR) [5], dynamic programing (DP) [6], particle swarm optimization (PSO) [7-9], and genetic algorithm (GA) [10]. The mentioned techniques have some benefit along with some disadvantages. It may be difficult to determine the global optimal solution with mathematical programming algorithms because SCUC is a mixed-integer non-convex optimization [11]-[12]. Due this drawback, evolutionary techniques have attracted a lots of attention to handle the SCUS problem. However, the effectiveness of the evolutionary techniques significantly related to their solution process. That means the solution can be vary on different techniques. Consequently, the performance along with the computational time are vary in the evolutionary techniques. Hence, in order to utilize the evolutionary technique, it is essential to select the algorithm carefully so that it can overcome the nonlinearity of the system.

Modified Genetic Algorithm Based on Multicellular Organisms Mechanisms (GAMOM) method is a novel evolutionary method [13-17]. It should be noted that, this algorithm has a sensible computation time and easy concept in comparison with the other existing evolutionary algorithms. Evolutionary algorithms are very popular in other engineering field as well [18-21]. Also, by combining them with other methods (such as fuzzy logic) can lead to an effective and high speed algorithm [22-25].

In this study, in order to solve the SCUC problem, the GAMOM method has been used. The main aim of this study is to reduce the total operating cost. It is worth to noting that in this paper, all the grid and generators constraints constraints are taken into consideration. Furthermore, spinning reserve is modeled to guarantee the satisfactory of operation under any

A. Yazdandoost Banizamani is with the Jahan Pardazesh Alborz Engineering Company Karaj – Iran (e-mail: ali.yazdandoost7@gmail.com).

P. Khazaei is with the Department of Electrical and Computer Engineering, Shiraz University of Technology, Shiraz, Iran. (e-mail: electronic.peyman@gmail.com).

R. Kamali is with the Department of Electrical and Computer Engineering, Shiraz University of Technology, Shiraz, Iran. (e-mail: kamali.rahim@gmail.com).

S. Saadatian is with the Department of Mechanical, Louisiana State University, Baton Rouge, USA. (e-mail: <u>ssaada1@lsu.edu</u>). This paper is accepted in IEEE WAC 2018.

load fluctuation [26-34]. It should be mentioned that, the reserve consideration can potentially increase the complexity of the SCUC problem and is difficult to be controlled by numerous existing evolutionary algorithms. To the best of the authors knowledge, this paper is the first paper that utilized the GAMOM algorithm in the power system operation problem. Results demonstrates the high superiority of the proposed algorithm.

## II. MATHEMATICAL MODELING

The main aim of the UC problem is to minimize the total generation cost. The total generation cost consists of the fuel and startup or shut down costs of the generating units [13-18].

$$minTC = \sum_{t \in \Omega_T} \sum_{i \in \Omega_g} f_i \left( p_{it} \right) I_{it} + SDU_{it}$$
(1)

where *TC*, *i*, *t*,  $\Omega_g$  and  $\Omega_T$  are the total cost, unit index, time, set of generating units and operating horizon respectively. It should be noted that the operating horizon is equal to 24 hours in this paper. The fuel startup and shutdown costs of unit *i* is shown with  $f_i(.)$  and  $SUD_i$  respectively. The power generation of the unit *i* in time *t* is shown with  $p_{it}$  and the binary variable which determines the ON/OFF status of unit *i* at time *t* is shown with  $I_{it}$ . The optimization problem is subjected to the following constraints.

#### A. Power Balance

At any time, the total generated power should be equal to demand. That means:

$$\sum_{i \in \Omega_g} p_{it} J_{it} \ge D_t \tag{2}$$

where  $D_t$  is the total power demand at time t.

## **B.** Generating Units limitation:

This limitation can be defined as follow:

$$\underline{p_i} J_{it} \le p_{it} \le \overline{p_i} J_{it} \tag{3}$$

This constraint ensures that the power output of the generating unit *i* is bounded by the unit's capacity. The minimum and maximum power generation of unit *i* is shown with  $\underline{p_i}$  and  $\overline{p_i}$ respectively. It should be mentioned that, if the unit *i* is OFF in the time period *t*,  $I_{it}$  is equal to zero and thus  $p_{it}$  is zero.

#### C. Ramp up and down limitation

It is crucial to consider the ramping-up and ramping-down limits of unit *i* while altering its power generation from time intervals (t-1) to *t*. This assumption will lead to the following constraint[19-38]:

$$p_{it} - p_{i(t-1)} \le RU_i + M\left(2 - I_{i(t-1)} - I_{it}\right)$$
(4)

$$p_{i(t-1)} - p_{it} \le RD_i + M\left(2 - I_{i(t-1)} - I_{it}\right)$$
(5)

where  $RU_i$  is the maximum ramp-up and  $RD_i$  is the maximum ramp-down rate of unit *I* in MW/hour, and *M* is a large value.

Startup/shutdown prices of the generating units play a very significant role in the total operating costs. Two types of cost are determined in the UC problem, the hot start and cold start. When the unit is not cool-down totally and essentials to be turned on over it is called as the hot start. Also, the cold-start refers to the condition when the unit is cool-down completely. The startup cost can be expressed as follows:

$$St_i = \sum_{k=t-T_i^{off} - T_i^{cold}}^{t-1} U_i^k SU_i^t$$
(6)

Where

$$f(x) = \begin{cases} SU_{i}^{hot} U_{i}^{t} \cdot (1 - U_{i}^{t-1}), & \text{if } St_{i}^{t} > 0\\ SU_{i}^{hot} U_{i}^{t} & \text{if } St_{i}^{t} = 0 \end{cases}$$
(7)

The shutdown cost equation can be determined with the same process.

## E. Spinning Reserve Constraints

Due to the unexpected disturbances, the power demand in time interval t can be vary. Simultaneously, generating units may could not offer more power due to their limitations. Therefore, to prevent grid blackout and satisfying the require demand, sufficient reserve needs to be scheduled by the generation units. [13-18]. Although this constraint can lead to complexity of the problem, but it can significantly improve the reliability and security of the grid. In this paper, to consider the spinning reserve, the following constraint is expressed as follows:

$$\begin{cases} SR_{up}^{t} = \sum_{i=1}^{N} \min\left(P_{i,\max} - P_{i}^{t}, M \times r_{i}\right) U_{i}^{t} \\ SR_{up}^{t} = \sum_{i=1}^{N} \min\left(P_{i}^{t} - P_{i,\min}^{t}, M \times r_{i}\right) U_{i}^{t} \end{cases}$$

$$\tag{8}$$

The spinning reserve requirements to support the unpredicted load increase or generation outrage is shown with  $SR_{up}$  and the

required spinning reserve to respond to the load reduction is shown with  $SR_{dn}$ . Also, the coefficient of the ramp rate is shown with r which is equal to 10, which means the power output of the generating unit can alter within 10 minutes' time interval.

## F. Voltage and Angle constraints

The voltage and angle of each feeder should be within a limit in any time as (9) and (10).

$$\underline{V} \leq V_{m,t} \leq V \tag{9}$$

$$\underline{\theta} \le \theta_{m,t} \le \theta \tag{10}$$

#### G. Power flow constraint:

The power flow of lines should be within the limit as (11).

$$S_{nm,t} \le \overline{S} \tag{11}$$

where n and m are feeder's nodes, and m represents as the feeder index.

## II. Proposed Genetic Algorithm based on Multicellular Organisms Mechanisms

The proposed GA follows mitosis and meiosis in the human cell. Previously, conventional GAs mimicked the meiosis processes on sexual chromosomes. In the proposed GA, the concept of mitosis for the asexual chromosomes will be added to GA. The flowchart for the proposed GA is illustrated in Fig.2. The proposed GA starts by producing chromosomes for the populations (population1 and population2) which are shown with  $N_1$  and  $N_2$  with the size of  $n_1$  and  $n_2$ . Chromosome generation is a complete random process, and the chromosomes for each population are produced independently.

Table I
General algorithm's parameters

Parameter	Definition	Number
$m_1$	Mitosis rate	[0,1]
$m_2$	Meiosis rate	[0,1]
$\alpha_1.m_1$	Ratio of chromosomes in $N_I$ that should place in $N_I$ '	[0,1]
$\alpha_2.m_2$	Ratio of chromosomes in $N_2$ that should place in $N_2$ '	[0,1]
$\beta_1.m_1$	Ratio of chromosomes in $N_2$ that should place in $N_1$ '	[0,1]
$\beta_2.m_2$	Ratio of chromosomes in $N_I$ that should place in $N_2$ '	[0,1]

The parameters are set after generating populations, The definition of parameters such as  $m_{l}$ ,  $m_{2}$ α1,  $\beta_{l}$ , β2, and their range is introduced in α2, Table 1. The parameters are important as they mix the chromosomes from population1 and population2 to make sub-population1 and sub-population2.

The two subpopulations are shown as  $N_1$  and  $N_2$ . The sizes of subpopulations are formulated as follows:

 $n'_{1} = \alpha_{1}.m_{1}.n_{1} + \beta_{1}.m_{1}.n_{2} \tag{12}$ 

$$n'_{2} = \alpha_{2}.m_{2}.n_{1} + \beta_{2}.m_{2}.n_{2} \tag{13}$$

The aim of the parameters is to determine how the algorithm collects sexual chromosomes and sexual chromosomes in to the subpopulation1 and subpopulation2 for mitosis and meiosis purposes.

A group of asexual chromosomes in  $N_1$  undergoes mitosis, which consists of duplication and mutation actions. At the same time, the  $N_2$  which consists of sexual chromosomes undergoes homologous recombination or crossover in meiosis phase I. There is a possibility of mutation in meiosis phase II. Normally, there is not a high rate of mutation in the mitosis and meiosis processes.

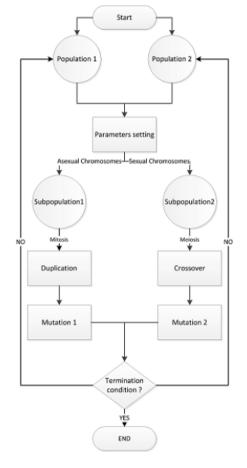


Fig .1. Flowchart of the proposed GA

In genetics, there are various factors for example exogenous (environmental factors) and endogenous (errors during DNA replications) which may be the reason for mutations. Mutations happen randomly. The randomness in mutations may have either no effect, alter the product of a gene, or prevent the gene from functioning appropriately. In the proposed algorithm, mutations have similar concept of randomness but the mutations in mitosis and meiosis are in different forms. The rate of mutation in mitosis is selected to be higher than meiosis to follow the natural mechanisms of cell division. At the end, after mutation in mitosis are going to  $N_1$ . Furthermore, the chromosomes at the end of meiosis are going to  $N_2$  based on elite characteristics of the chromosomes. Both mitosis and meiosis execute at the same time in parallel.

It should be mentioned that, the proposed method has an advantage over the other methods which is the migration of the chromosomes between the subpopulations. However, it has a significant dissimilarity between proposed model and Island model which has been introduced in the literature. In Island model, all subpopulations are searching for the optimum solution and sometimes the island with disfavored results die and the island with the superior results survive. However, in this model none of the subpopulations are going to be deactivated. It is a mechanism to keep the variety in the population. Fig. 1 show the flowchart of the proposed algorithm.

## **IV. Simulation Result**

In order to validates the effectiveness of the proposed algorithm, two different cases are considered as follows:

## Case1: Solving the US by considering three generation units.

## Case2: Solving the SCUS by considering ten generation units.

*Case1:* In this case a small networked is considered which includes three generation units. Table II describes the characteristics of distributed generators (DGs). Fig.2 demonstrates the required energy for the day-ahead market.

Table II Characteristics of DGs		
Characteristics of DGs		

Туре	Min-Max Capacity (kW)	Cost (\$/kWh)	Up/Down	Min Up/down Time (h)		
DG1	20-100	0.1	100	3		
DG2	40-50	0.2	40	3		
DG3	1-25	0.4	0	3		

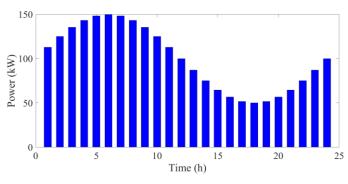


Fig. 2, Power demand for day-ahead in case 1.

Fig. 3 represents the optimal output power of DGs. Based on this figure, the cheapest unit (unit 1) is committed to generate power in many hours a day. Accordingly, unit 2 generates more power in comparison with unit 3. That means units' status is just based on the economic consideration which can demonstrates the effectiveness of the proposed algorithm.

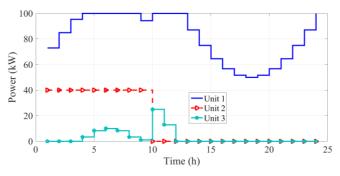


Fig. 3, Optimal output power of DGs in case1.

Moreover, the convergence speed of the proposed algorithm is compared with the particle swarm optimization (PSO) method as one of the well-known heuristics techniques in Fig. 4.

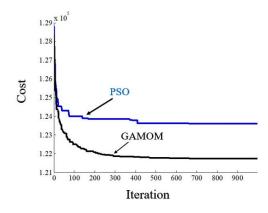


Fig. 4, Compare the convergence speed of GAMOM and PSO

Also, the total operation cost by the proposed algorithm is compared with other methods (heuristic and mathematical such as mixed integer linear programming (MILP)) in Table III.

Table III Total Operation Costs						
Methods	Operation Cost Of Best Solution	Operation Cost Of Worst Solution				
PSO	36569.7557	38269.7557				
GA	36269.7557	37369.7557				
GAMOM	35279.7557	35289.7557				
MILP	35269.7557	-				

Simulation results and final operation cost of case 1 can prove the effectiveness of the proposed technique in comparison with other heuristic methods.

**Case2.** In this case, the optimal output powers of 10 generation units in the IEEE 39-bus test networked. Fig. 5 show the single line diagram of IEEE 39-bus test network which includes 10 generation units. Also, the total load demand of day-ahead is represents in Fig. 6. According to the simulation results, the there is no constraint violation that means the proposed algorithm is able to solve the complex problems as well.

Table IV presents the characteristics of generation units in case 2. According to the table, unit 1 the cheapest unit in comparison with others.

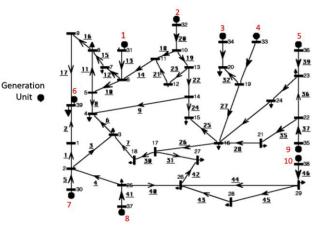


Fig. 5, IEEE 39 bus test network with 10 units

Table IV Generation units charectristcis for case 2

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Unit 10
$a_i$	1000	970	700	680	450	370	480	660	665	670
$b_i$	19.6	17.26	16.2	16.5	19.7	22.26	27.4	25.92	27.27	27.79
<i>C</i> ,	0.00048	0.00031	0.002	0.00211	0.00398	0.00712	0.00079	0.00413	0.00222	0.00173
P <sub>max</sub>	455	455	130	130	162	80	85	55	55	55
P <sub>min</sub>	150	150	20	20	25	20	25	10	10	10
r	9.1	9.1	2.6	2.6	3.24	1.6	1.7	1.1	1.1	1.1
RU	227.5	227.5	65	65	81	40	42.5	27.5	27.5	27.5
RD	227.5	227.5	65	65	81	40	42.5	27.5	27.5	27.5
TON	8	8	5	5	6	3	3	1	1	1
TOFF	8	8	5	5	6	3	3	1	1	1
T <sub>Cold</sub>	5	5	4	4	4	2	2	0	0	0
SUCold	9000	9000	1100	1120	1800	340	520	60	60	60
SUHot	4500	5000	550	560	900	170	260	30	30	30
In.State	8	8	-5	-5	-6	-3	-3	-1	-1	-1

is \$555997.00.

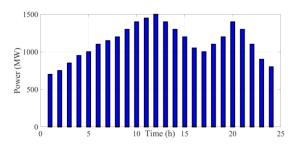


Fig. 6, Power demand for day-ahead in case 2.

Table V represents the status of generation units for the dayahead. According to this table, where the status is one means the unit is committed and should be ON during this hour. Moreover, zero means the unit is OFF. For instance, unit one is ON entire the day. As another example, units 3 is OFF for 7 hours, after that it is committed for 14 hours, then turned OFF for 3 hours. The output power of generation units is represented in Fig. 7. It is worth noting that unit 1 is ON for the entire horizon with its maximum capacity due to its cheap price.

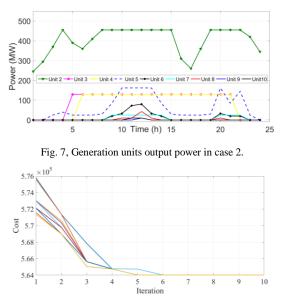


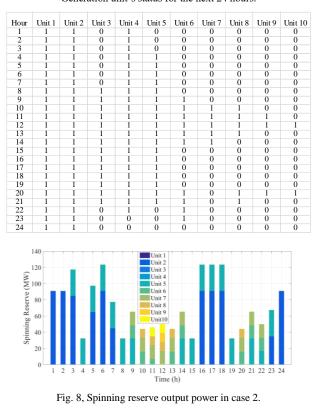
Fig. 9, Convergence speed of GAMOM in case 2.

Table V Generation unit's status for the next 24 hours.

Spinning reserve is one of most challenges in the SCUC problem and can has a significant effect on the cost function.

Fig. 8, demonstrates the optimal output power of each generation unit as the spinning reserve. As it can see, the portion

of the unit1 is more than others due to its cheapest price. Moreover, the convergence speed of the proposed algorithm show in Fig. 9. According to the figure, the optimal cost is obtained after just five iterations that can prove the high speed of the proposed algorithm. The total operation cost of this case



# V. Conclusion

In this paper, a novel modified GA based on GAMOM algorithm is applied to solve the SCUC problem. GAMOM is an evolutionary algorithm that includes two phases, GA phase and modified GA phase. The proposed algorithm is applied to

5

two different cases as UC and SCUC problems. The results demonstrate the effectiveness and high performance of the proposed technique. Moreover, the convergence speed of the proposed algorithm is compared with PSO algorithm where it has a superiority as well.

#### References

- N\_ P\_ Padhy, "Unit commitment-A bibliographical survey," IEEE Trans\_ Power Syst, vol. 19, no\_ 2, pp\_ 1196-1205, May 2004\_
- [2] H. Davarikia, M. Barati, F. Znidi, K. Iqbal, "Real-Time Integrity Indices in Power Grid: A Synchronization Coefficient Based Clustering Approach," arXiv Preprint arXiv:1804.02793, 2018.
- [3] Liu, Xian, and Hamzeh Davarikia. "Optimal Power Flow with Disjoint Prohibited Zones: New Formulation and Solutions." arXiv preprint arXiv:1805.03769 (2018).
- [4] H. Davarikia, "Investment Plan Against Malicious Attacks on Power Networks: Multilevel Game-Theoretic Models with Shared Cognition." PhD diss., University of Arkansas at Little Rock, 2017.
- [5] W\_ L. Peterson and S\_ R Brammer, "A capacity based Lagrangian relaxation unit commitment with ramp rate constraints," in IEEE Transactions on Power Systems, vol. 10, no. 2, pp. 1077-1084, May 1995.
- [6] Mina Yazdandoost, Ali Yazdandoost, Fakhri Akhoonili, Farshid Sahba, "Smart tractors in pistachio orchards equipped with RFID", presented at the 2016 World Automation Congress, 2016.
- [7] T. O. Ting, M. V. C. Rao, and C. K. Loo, "A novel approach for unit commitment problem via an effective hybrid particle swarm optimization." IEEE Trans. Power Syst., vol. 21, no. I, pp. 411-418, Feb. 2006.
- [8] Z. L. Gaing, "Discrete particle swarm optimization algorithm for unit commitment," in Proc. IEEE Power Eng. Soc. General Meeting, Jul. 2003, vol. I, pp. 13-17.
- [9] W. Xiong, M. J. Li, and Y. Cheng, "An improved particle swarm optimization algorithm for unit commitment," in Proc. ICICTA 2008.
- [10] P. Bajpai and S. N. Singh, "Fuzzy adaptive particle swarm optimization for bidding strategy in uniform price spot market," IEEE Trans. Power Syst., vol. 22, no. 4, pp. 2152- 2160, Nov. 2007.
- [11] Ashkaboosi, Maryam, Seyed Mehdi Nourani, Peyman Khazaei, Morteza Dabbaghjamanesh, and Amirhossein Moeini. "An optimization technique based on profit of investment and market clearing in wind power systems." American Journal of Electrical and Electronic Engineering 4, no. 3 (2016): 85-91.
- [12] Khazaei, Peyman, Morteza Dabbaghjamanesh, Ali Kalantarzadeh, and Hasan Mousavi. "Applying the modified TLBO algorithm to solve the unit commitment problem." In World Automation Congress (WAC), 2016, pp. 1-6. IEEE, 2016.
- [13] Amin Sahba, Yilin Zhang, Marcus Hays, and Wei-Ming Lin. "A Real-Time Per-Thread IQ-Capping Technique for Simultaneous Multithreading (SMT) Processors." In Information Technology: New Generations (ITNG), 2014 11th International Conference on, pp. 413-418. IEEE, 2014.
- [14] Amin Sahba, and John J. Prevost. "Hypercube based clusters in Cloud Computing." In World Automation Congress (WAC), 2016, pp. 1-6. IEEE, 2016.
- [15] Mahdi Bagheri, Mehdi Madani, Ramin Sahba, and Amin Sahba. "Real time object detection using a novel adaptive color thresholding method." Proceedings of the 2011 international ACM workshop on Ubiquitous meta user interfaces, pp. 13-16. ACM, 2011.
- [16] Amin Sahba, Ramin Sahba, and Wei-Ming Lin. "Improving IPC in simultaneous multi-threading (SMT) processors by capping IQ utilization according to dispatched memory instructions." In World Automation Congress (WAC), 2014, pp. 893-899. IEEE, 2014.
- [17] Ramin Sahba, "Hashing for fast IP address lookup utilizing inter-key correlation." The University of Texas at San Antonio, 2013.
- [18] Sun, C., and V. Jahangiri. "Bi-directional vibration control of offshore wind turbines using a 3D pendulum tuned mass damper." Mechanical Systems and Signal Processing 105 (2018): 338-360.
- [19] Jahangiri, Vahid, and Mir Mohammad Ettefagh. "Multibody Dynamics of a Floating Wind Turbine Considering the Flexibility Between Nacelle and

Tower." International Journal of Structural Stability and Dynamics (2017): 1850085.

- [20] Jahangiri, Vahid, Hadi Mirab, Reza Fathi, and Mir Mohammad Ettefagh. "TLP Structural Health Monitoring Based on Vibration Signal of Energy Harvesting System." Latin American Journal of Solids and Structures 13, no. 5 (2016): 897-915.
- [21] Mirab, Hadi, Reza Fathi, Vahid Jahangiri, Mir Mohammad Ettefagh, and Reza Hassannejad. "Energy harvesting from sea waves with consideration of airy and JONSWAP theory and optimization of energy harvester parameters." Journal of Marine Science and Application 14, no. 4 (2015): 440-449.
- [22] Dabbaghjamanesh, M., A. Moeini, M. Ashkaboosi, P. Khazaei, and K. Mirzapalangi. "High performance control of grid connected cascaded H-Bridge active rectifier based on type II-fuzzy logic controller with low frequency modulation technique." International Journal of Electrical and Computer Engineering 6, no. 2 (2016): 484.
- [23] Rakhshan, Mohsen, Navid Vafamand, Mokhtar Shasadeghi, Morteza Dabbaghjamanesh, and Amirhossein Moeini. "Design of networked polynomial control systems with random delays: sum of squares approach." International Journal of Automation and Control 10, no. 1 (2016): 73-86
- [24] M. Dabbaghjamanesh, S. Mehraeen, A. Kavousifard and M. A. Igder, "Effective scheduling operation of coordinated and uncoordinated windhydro and pumped-storage in generation units with modified JAYA algorithm," 2017 IEEE Industry Applications Society Annual Meeting, Cincinnati, OH, 2017, pp. 1-8.
- [25] Khazaei, P., S. M. Modares, M. Dabbaghjamanesh, M. Almousa, and A. Moeini. "A high efficiency DC/DC boost converter for photovoltaic applications." International Journal of Soft Computing and Engineering (IJSCE) 6, no. 2 (2016): 2231-2307.
- [26] S. Jafari-Shiadeh, M. Ardebili, and P. Moamaei, "Three-dimensional finite-element-model investigation of axial-flux PM BLDC machines with similar pole and slot combination for electric vehicles", Proceedings of Power and Energy Conference, Illinois, pp. 1–4, 2015
- [27] Dabbaghjamanesh, Morteza, Shahab Mehraeen, Abdollah Kavousi Fard, and Farzad Ferdowsi. "A New Efficient Stochastic Energy Management Technique for Interconnected AC Microgrids." arXiv preprint arXiv:1803.03320 (2018).
- [28] Ghaffari, Saeed, and Maryam Ashkaboosi. "Applying Hidden Markov Model Baby Cry Signal Recognition Based on Cybernetic Theory." *IJEIR* 5, no. 3 (2016): 243-247.
- [29] Ghaffari, Saeed, and M. Ashkaboosi. "Applying Hidden Markov M Recognition Based on C." (2016).
- [30] S. Jafarishiadeh, M. Ardebili, A. Nazari Marashi, "Investigation of pole and slot numbers in axial-flux pm bldc motors with single-layer windings for electric vehicles," 24th Iranian Conference on Electrical Engineering (ICEE), pp. 1444-1448, 2016.
- [31] Dabbaghjamanesh, Morteza, Abdollah Kavousi-Fard, and Shahab Mehraeen. "Effective Scheduling of Reconfigurable Microgrids with Dynamic Thermal Line Rating." *IEEE Transactions on Industrial Electronics* (2018).
- [32] Ashkaboosi, Maryam, Farnoosh Ashkaboosi, and Seyed Mehdi Nourani. "The Interaction of Cybernetics and Contemporary Economic Graphic Art as" Interactive Graphics"." (2016).
- [33] H. Davarikia, F. Znidi, M. R. Aghamohammadi, K. Iqbal. Identification of coherent groups of generators based on synchronization coefficient. 2016 IEEE Power and Energy Society General Meeting (PESGM). 2016:1-5.
- [34] F. Znidi, H. Davarikia and K. Iqbal, "Modularity clustering based detection of coherent groups of generators with generator integrity indices," in 2017 IEEE Power & Energy Society General Meeting, 2017, pp. 1-5.
- [35] Farshid Sahba et al., "Wireless Sensors and RFID in Garden Automation", International Journal of Computer and Electronics Research, vol. 3, no. 4, August 2014
- [36] Farshid Sahba, Zahra Nourani, "The diagnosis of lumbar disc disorder by MR image processing and data mining", presented at the 2016 World Automation Congress, 2016
- [37] Mahdi Keshavarz Bahaghighat, Farshid Sahba, Ehsan Tehrani, "Textdependent Speaker Recognition by combination of LBG VQ and DTW for persian language", Intermitornl Jounral of Computer applications (0975 - 8887) volume51-no.16, August 2012
- [38] Farshid Sahba, "Museum automation with RFID", Proceedings of the 2014 World Automation Congress (WAC), pp. 19-22, Aug 2014