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TEACHING LEARNING BASED OPTIMIZATION: APPLICATION AND VARIATION

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Abstract - The Teaching Learning Based Optimization (TLBO) algorithm is one of the important algorithms which is based on effect of teacher on outputs of learner class. In literature TLBO algorithm is used to solve the large scale complex problems and real time applications. The purpose of this algorithm ranging from different application like scheduling, hydrothermal energy, water forecasting in urban development for forecasting the demand of water. This report presents a brief intro to the TLBO algorithm and its applications as well as the variations. The main purpose of this paper is to overview of applications solved using TLBO algorithm and findings of remarkable point to improve the solution.

Keywords—Teaching Learning Based Optimization (TLBO), Application and variants of TLBO

I. INTRODUCTION

To figure out the real world problems, engineering optimization problems, the traditional approaches such as steepest decent, linear scheduling, dynamic scheduling, etc. are not capable due to its limitations such as accumulation of noise data, inflexible structure. The nature inspired optimization techniques are best suitable for these kind of problems like scheduling, forecasting, large scale optimization problems, problems that have many local optima [1, 2]. In paper [3] has described the brief overview of different nature inspired techniques such as, Genetic algorithm is a work based on survival of the fittest. Memetic algorithm works on the basis of the survival of fittest and most experienced. Particle swarm optimization works on the basis of the behavior of swarm of birds. Likewise the Ant colony optimization works behavior of ant towards the food using shortest path. Shuffled Frog Leaping algorithm works on the principle of communication among the frogs which works in groups. The algorithms like Artificial Bee Colony (ABC), Harmony search (HS) are also used to solve the optimization problems.

The primary limitation of the mentioned algorithms to solve the optimization problem is all algorithms are required the parameter for proper working. Proper selection is important for optimum result. Hence there should be need of parameter less algorithm where algorithm are not depends on any parameter hence there is no any effect on solution [2]. The Teaching Learning Based Optimization (TLBO) [4] algorithm introduce in 2012 which is parameter less algorithm effectively used to solve the engineering optimization problem.

The paper is organized in remaining part as follows: Section II gives brief about TLBO algorithm with brief idea and a flow chart of the algorithm. Section III is about overview about the application and problem solved using TLBO algorithm. Section IV describes the available variants of TLBO algorithm. That last section is Section V, is about discussion of conclusion.

II. TEACHING LEARNING BASED OPTIMIZATION (TLBO)

Teaching Learning Based Optimization (TLBO) is a population based, parameter less algorithm proposed in [2, 4], the teaching-learning process is based on effect of teacher on output of learner class. The population for TLBO algorithm is considered as a group of learners.

The TLBO algorithm works into two phases– 'Teacher Phase' and 'Learner Phase'. In the algorithm, learning of the teacher phase of the teacher or instructor and learning of Learner Phase is between learners in various ways.

The working of teacher phase is as follows: after initialization of population, calculate the mean of each subject and accordingly modify (improve) result of each student for improvement the overall mean of class. M_i is the mean of each subject, T_i is the teacher selected as M_{new}. It tries to move mean M_i towards, its own level. The solution of the population is updated according to the difference between the existing main and the new meaning given by

$$Difference\ Mean_i = r_i(M_{new} - T_f M_i) \quad (1)$$

Where,

r_i = any random number between 0 and 1
T_f =Teaching factor
M_i = it is mean of population at particular iteration
M_{new} = best result that is teacher in population

In equation (1) the value of teaching factor is probably the part which decides the mean value to be changed. The value of r_i is random no within range of 0 and 1. The value of teaching factor T_F can be either 1 or 2 and decided randomly with equal probability as,

$$T_f = round[1 + rand(0,1)\{2 - 1\}] \quad (2)$$

This difference modifies the solution according to the following equation

$$X_{new} = X_{old} + Difference\_Mean \quad (3)$$

The working of Learning Phase as follows:
Learner can increase their knowledge by following ways:

- ✓ Input through the teacher to increase the knowledge
- ✓ Another way is the interaction between them

Select randomly another Xi and Xj such way that (i≠j)

$$\text{If } f(X_i) < f(X_j)$$
$$X_{new} = X_{old,i} + r_i(X_i - X_j)$$
$$\text{Else } f(X_i) > if\ f(X_j)$$
$$X_{new} = X_{old,i} + r_i(X_j - X_i)$$

Accept X_{new} if it gives a better function value.
And check termination condition, also finalize the solution.
Figure 1 shows the flow chart of the TLBO algorithm.

III. DIFFERENT PROBLEMS/APPLICATIONS SOLVED BY TLBO ALGORITHM

TLBO algorithm widely applied to engineering optimization problem, linear scale problems and performance tested over the different benchmark function as well as for different problems. There is less literature available for the TLBO algorithm applied to the combinatorial problems like scheduling. The main aim of development of metaheuristics algorithm (GA, PSO, ACO etc.) The author mentioned the same problem in [5], also author mentioned detailed literature overview about hoe TLBO applied to the combinatorial problems with the advantages. Scheduling is most important and complicated the combinatorial search problem.

A. Flow Shop and Job Shop Scheduling Problem [5]:

In paper [6], the Adil Baykasog˘luet. et.al proposed TLBO algorithm for problem of flow shop scheduling and job shop scheduling problem. Author uses the Giffler and Thompson (G&T) algorithm for construction of active scheduling in the TLBO search. The mentioned problem gives the idea how to apply the TLBO algorithm for combinatorial problems like Flow shop Scheduling and Job shop Scheduling and idea about the performance of the algorithm over the problem. The makespan criterion for flow shop scheduling is still a hot topic of research [8].

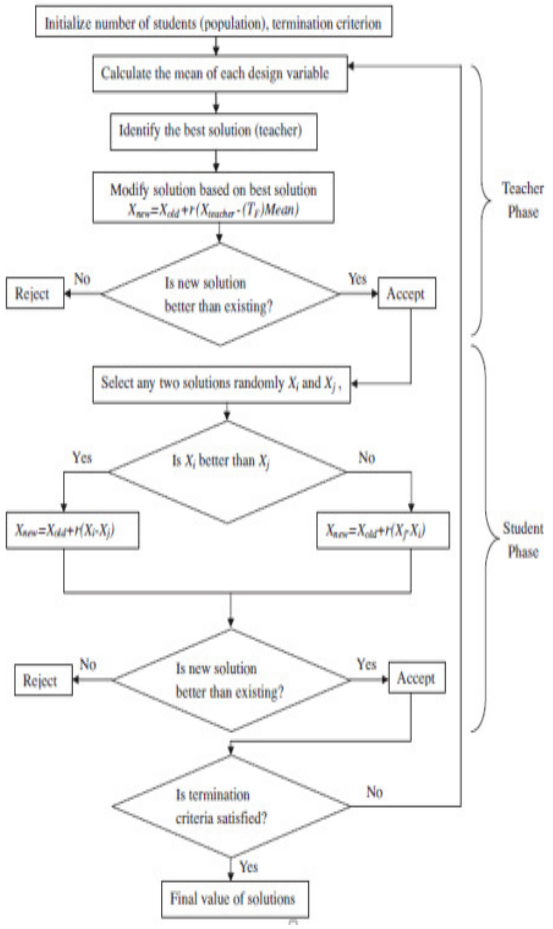

Fig. 1 Flow Chart of TLBO algorithm\

B. Job Shop Scheduling Problem :

In paper [7], the author explains about the optimization of JSSP. The goal of the author is to find the job operation scheduling list that minimizes the make span value. The results are compared with PSO, ABC, and MA. The advantage is TLBO algorithm cannot trap in local minima, as problem size increases, it is able to give the most optimal solution.

C. Permutation Flow Shop Scheduling Problem :

In paper [8, 9], the author explain the permutation flow shop scheduling using TLBO. The author combines TLBO and VNS algorithm for fast solution improvement to hybrid Teaching–Learning-Based Optimization algorithm (HTLBO). This proposed algorithm used for PFSP to determine the job sequence with minimization of make span criterion. With the experiment result author shows it works well and it is an effective approach. The future scope is for implementing the methodology for the Multiobjective flow shop and hybrid flow shop scheduling problems.

D. Optimal Multi Distributed Generator (DG) Placement Problem:

In paper [10], the author proposed TLBO algorithm for solving the optimal multi Distributed Generator (DG) placement problem which was defined by the author for minimization of loss, capacity release of transmission lines and voltage profile improvement and it was working in two stages. The obtained results have been compared with other optimization algorithms like GA (Genetic Algorithm) and PSO (Particle Swarm Optimization). The experimental Results showed significant reduction in power loss and line flows and significant improvement in voltage profile.

E. Short Term Hydro-thermal Optimal Scheduling:

In paper [11, 16], the author solves the Short Term Hydro-thermal Optimal Scheduling using TLBO algorithm. The author formulates the problem as minimization of the cost and emission units. The author combines the approach of DE and TLBO algorithm to solve the problem. The proposed method is tested on scenarios of a hydro-thermal power system. Author tested results and conclude that the results have overall enhanced the overall search ability of the algorithm.

F. Flexible Job-Shop Scheduling Problem:

In Paper [12] address the Flexible Job-Shop Scheduling Problem with fuzzy processing time using TLBO approach. Effectiveness of algorithm is shown by comparative study and analysis of result with other algorithms like ABC, PSO.

G. Realistic flow shop scheduling problem:

In Paper [1] describe the Discrete TLBO for realistic flow shop scheduling problem by modifying the teacher and learner phase. The experiment carried out for 90 realistic flow shop rescheduling instances with other efficient algorithms which indicate that the proposed algorithm is capable in terms of its searching quality, robustness, and efficiency.

H. Mitigation of Transmission Losses:

In Paper [13] represents the problem Mitigation of Transmission Losses with Voltage Stability Consideration using TLBO. The problem is solved for minimization of transmission loss and voltage stability by rescheduling reactive power control.

I. Unconstrained optimization Problems based on GPGPU TLBO:

In paper [14], author introduce the GPGPU based TLBO algorithm for unconstrained optimization problem for improvisation of results and result compare with ABC algorithm. Here author concludes that quality of solution obtained by TLBO is better as compared to ABC algorithm.

These are the some applications/problems from existing literature where TLBO algorithm is used and it gives the efficient results rather that other evolutionary algorithms. Next section gives more idea about the available variants of TLBO algorithms which introduce with different aim such as is improvement of the performance.

IV. VARIENTS OF TLBO ALGORITHM:

A. non-dominant sorting TLBO (NSTLBO):

In paper [15], the author describes Optimization of fused deposition modelling process using TLBO algorithm. In this work author works on single and Multiobjective optimization problem widely used rapid prototyping (RP) process. Here author proposed new variant that is non-dominant sorting TLBO (NSTLBO) algorithm which was proposed to solve the Multiobjective optimization problems of the fused decomposition (FDM) process. In this work the population is sorted after the evaluation of population in teacher phase and the learner phase after evaluation of population in respective phase. The non-dominated solutions are identify in the first sorting run and assigned rank one also it is deleted from solution. The remaining solutions sorted, and procedure is repeated until all the solutions set P are sorted and ranked.

B. Elitist TLBO algorithm

In paper [17, 18], the elitist TLBO algorithm is proposed for global function optimization. This variation is proposed by R. Venkata Rao and Vivek Patel [17]. The concept of elitism is utilized every generation the worst solutions are replaced by the elite solutions. In the TLBO algorithm, at the end of learner phase, if the duplicate solutions exist after replacing the worst solutions with elite solutions then it is necessary to modify the duplicate solutions in order to avoid trapping in the local optima.

C. Improved TLBO:

In paper [19, 20], author introduce the Improved TLBO algorithm in which the no of teacher is decided on basis of group of learner. The entire group of learner split into different group of learner according to their level and individual teacher assigned to the group where teacher responsible for improvisation of result. Author compared the algorithm result with Basic TLBO algorithm and on basis of experimental result they shows ITLBO work better than TLBO because of multiple teacher tries to improve the result. Here Teaching factor is also calculated based on best result. Same algorithm is used to design the linear phase- Finite Impulse Response (FIR) filters in [21].

D. Multi Objective-ITLBO and Multi Objective -TLBO:

In paper [21] author Introduce MO-ITLBO to solve the Multiobjective problem by using the grid based approach while paper [22] describe the MO-TLBO and uses the concept of non-determinant sorting and ranking process after evaluation of population.

E. Group Leader Dominated-TLBO:

In paper [23], the author introduce Group Leader Dominated-TLBO where learners are not directly communicate with each other. Each learner is assigned to at least one group where group leader is responsible for improvisation of learner knowledge. Teacher phase of LTLBO same as TLBO only modification is in only learner phase where each learner can be member of more than one group , so to do this the concept of neighbourhood used from PSO and ring topology.

F. learning experience –TLBO:

In paper [24], learning experience –TLBO introduce to improve the global performance of the TLBO algorithm. In teacher phase, according to random probability, learner improve the knowledge the by utilizing mean information of class. In learner Phase, the learner can learns knowledge from another learner which is randomly selected from the group of class.

G. TLBO-with crossover operation:

In paper [25], author introduces the TLBO-with crossover operation for performance improvement. The crossover operation is used in teaching phase of algorithm. The TLBOC and its purpose is to amend the local and global search capability of the original TLBO algorithm.

H. Co-Evolutionary TLBO algorithm:

In paper [26], a co-evolutionary teaching-learning-based optimization (CTLBO) algorithm is proposed. In this paper author describe the stochastic resource-constrained project scheduling problem (SRCPSP). Co-evaluation isconsidered as the evaluation of two or more population simultaneously by using crossover operation in teacher phase

These are the present literature of variant of TLBO used for different application/problems and some variant are introduced and applied to standard benchmark function.

V. CONCLUSION:

With the study of present literature of TLBO algorithm, it is observed that few resources available for complex combinatorial problems like scheduling. Most of the literature available where author applied algorithm to large scale optimization problems ranging from the problems from different stream such as mechanical, electronics, electrical, urban development for demand forecasting and result compared with other evolutionary algorithm like (GA,PSO,ABC). Next we presented variant of TLBO algorithm used for improvement of performance and quality of solution. From the present literature of applications and variants of TLBO, it is clear that TLBO algorithm gives more optimal solution than the other evolutionary algorithm like (GA, PSO, and ABC). The problems are need to solved using Multiobjective algorithms which are efficiently produce quality solutions, so this part needs to take consideration and need to focus of the study with Multiobjective problem.

The TLBO algorithm gives more optimal solution as problem size increased because the search space increased. The ITLBO gives more efficient results which compared with TLBO algorithm because the number of teacher is increased. This algorithm is possibly work more efficiently in parallel due to the learner assigned to teacher and evaluates them individual. So in future the study is required to address the complex combinatorial problems like scheduling using TLBO algorithm and it's variation due to its capability to obtain quality solution.

REFERENCES

[1] Li, Jun-qing, Quan-ke Pan, and Kun Mao. "A discrete teaching-learning-based optimisation algorithm for realistic flowshop rescheduling problems." Engineering Applications of Artificial Intelligence 37 (2015): 279-292.

[2] Rao, R. V., V. J. Savsani, and D. P. Vakharia. "Teaching–learning-based optimization: an optimization method for continuous non-linear large scale problems." Information Sciences 183, no. 1 (2012): 1-15.

[3] Elbeltagi, Emad, Tarek Hegazy, and Donald Grierson. "Comparison among five evolutionary-based optimization algorithms." Advanced engineering informatics 19, no. 1 (2005): 43-53.

[4] Rao, Ravipudi V., Vimal J. Savsani, and D. P. Vakharia. "Teaching–learning-based optimization: a novel method for constrained mechanical design optimization problems." Computer-Aided Design 43, no. 3 (2011): 303-315.

[5] Šeda, Miloš. "Mathematical models of flow shop and job shop scheduling problems." World Academy of Science, Engineering and Technology 1, no. 31 (2007): 122-127.

[6] Baykasoğlu, Adil, Alper Hamzadayi, and Simge Yelkenci Köse. "Testing the performance of teaching–learning based optimization (TLBO) algorithm on combinatorial problems: Flow shop and job shop scheduling cases." Information Sciences 276 (2014): 204-218.

[7] Keesari, H. S., and R. V. Rao. "Optimization of job shop scheduling problems using teaching-learning-based optimization algorithm." OPSEARCH 51, no. 4 (2014): 545-561.

[8] Xie, Zhanpeng, Chaoyong Zhang, Xinyu Shao, Wenwen Lin, and Haiping Zhu. "An effective hybrid teaching–learning-based optimization algorithm for permutation flow shop scheduling problem." Advances in Engineering Software 77 (2014): 35-47.

[9] https://www.researchgate.net/publication/265015440

[10] Kumar Ganivada, Phanindra, and Chintham Venkaiah. "Optimal placement and sizing of multi distributed generators using teaching and learning based optimization." In Smart Electric Grid (ISEG), 2014 International Conference on, pp. 1-6. IEEE, 2014.

[11] Xingwen, Jiang, and Zhou Jianzhong. "Hybrid DE-TLBO algorithm for solving short term hydro-thermal optimal scheduling with incommensurable objectives." In Control Conference (CCC), 2013 32nd Chinese, pp. 2474-2479. IEEE, 2013.

[12] Xu, Ye, Ling Wang, Sheng-yao Wang, and Min Liu. "An effective teaching–learning-based optimization algorithm for the flexible job-shop scheduling problem with fuzzy processing time." Neurocomputing 148 (2015): 260-268.

[13] Singh, Prashant, L. S. Titare, and L. D. Arya. "Mitigation of transmission losses with voltage stability consideration using TLBO." In Power and Energy Systems Conference: Towards Sustainable Energy, 2014, pp. 1-5. IEEE, 2014.

[14] Mane, Sandeep U., Rajshree Omane, and Aprupa Pawar. "GPGPU based teaching learning based optimization and artificial bee colony algorithm for unconstrained optimization problems." In Advance Computing Conference (IACC), 2015 IEEE International, pp. 1056-1061. IEEE, 2015.

[15] Rao, R. Venkata, and Dhiraj P. Rai. "Optimization of fused deposition modeling process using teaching-learning-based optimization algorithm." Engineering Science and Technology, an International Journal (2015).

[16] Roy, Provas Kumar. "Teaching learning based optimization for short-term hydrothermal scheduling problem considering valve point effect and prohibited discharge constraint." International Journal of Electrical Power & Energy Systems 53 (2013): 10-19.

[17] Rao, R., and Vivek Patel. "An elitist teaching-learning-based optimization algorithm for solving complex constrained optimization problems." International Journal of Industrial Engineering Computations 3, no. 4 (2012): 535-560.

[18] Rajasekhar, Anguluri, Rapol Rani, Kolli Ramya, and Ajith Abraham. "Elitist Teaching Learning Opposition based algorithm for global optimization." In Systems, Man, and Cybernetics (SMC), 2012 IEEE International Conference on, pp. 1124-1129. IEEE, 2012.

[19] Rao, R. Venkata, and Vivek Patel. "An improved teaching-learning-based optimization algorithm for solving unconstrained optimization problems." Scientia Iranica 20, no. 3 (2013): 710-720.

[20] Sharma, Shekhar, Sumant Katiyal, and L. D. Arya. "An Improved Teaching-Learning-Based Optimization Algorithm Applied to the Design of Linear Phase Digital FIR Filter."

[21] Patel, Vivek K., and Vimal J. Savsani. "A multi-objective improved teaching–learning based optimization algorithm (MO-ITLBO)." Information Sciences (2014).

[22] Zou, Feng, Lei Wang, Xinhong Hei, Debao Chen, and Bin Wang. "Multi-objective optimization using teaching-learning-based optimization algorithm." Engineering Applications of Artificial Intelligence 26, no. 4 (2013): 1291-1300.

[23] Chen, Chang-Huang. "Group Leader Dominated Teaching-Learning Based Optimization." In Parallel and Distributed Computing, Applications and Technologies (PDCAT), 2013 International Conference on, pp. 304-308. IEEE, 2013.

[24] Zou, Feng, Lei Wang, Xinhong Hei, and Debao Chen. "Teaching–learning-based optimization with learning experience of other learners and its application." Applied Soft Computing 37 (2015): 725-736.

[25] Zhao, Xiu-hong. "Teaching-learning based optimization with crossover operation." In Control and Decision Conference (CCDC), 2015 27th Chinese, pp. 3071-3075. IEEE, 2015.

[26] Zheng, Huan-yu, Ling Wang, and Sheng-yao Wang. "A co-evolutionary teaching-learning-based optimization algorithm for stochastic RCPSP." In Evolutionary Computation (CEC), 2014 IEEE Congress on, pp. 587-594. IEEE, 2014.