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MUTI-OBJECTIVE OPTIMIZATION ALGORITHMS FOR FLOW SHOP SCHEDULING PROBLEMS: A LITERATURE REVIEW

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Abstract

The scheduling problems are the unavoidable ones, and in the present situation required to explain various goals, henceforth regularly known as NP-Hard problems, for each industry in the market. Advanced algorithms are profoundly prescribed for scheduling as they are fit to convey optimal or near optimal ideal solutions. This paper conveys the utilizations of cutting edge algorithms in various production systems.The literature survey centers on the currently created algorithms with an objective such as minimizing the completion time, tardiness, earliness and so on, with various kinds of newly developed optimization algorithms. In the present examination, one-machine and two-machine flow shop scheduling variations with blocking, preemption and explanatory examination of minimization of makespan time are considered as the structure. This exhaustive literature is portraying the nitty gritty clarification and point of view of scheduling problems for multi-objective optimization algorithms. This paper is alluding to the scientific classification of heuristics algorithms for MFSP booking.The variations and hybridization for more proficient and successful algorithms have dependably pulled in researchers and is a regarded territory of future research. A portion of the difficulties, for example, overutilization of goals, end criteria and others have additionally been portrayed in the paper.

Keywords:*Advanced algorithms, Decision models,Heuristics approach, Multi-objective scheduling*

1. Introduction

Each association faces a difficulty in choosing one best option out of numerous accessible, which will encourage them to most ideal outcomes. Advanced algorithms are the ongoing responses for deciding the near-optimal solutions for the different scheduling conditions, may be manufacturing or management. These algorithms serve as evaluation process, which maximizes or minimizes the value of objective function. It demands the efficient allocation of limited resources are usually solved by using optimization algorithms. There are various steps which are involved in modeling of algorithm, such as recognizing the output.It is defining a problem, construction of model, solving the model, validating the model and implementing one solution There are various objectives such as minimizing the makespan, total flow time, earliness, tardiness and so on, which need to be

fulfilled in order to maximize the efficiency of the system. Various types of advanced algorithms are available and used for these objectives such as genetic algorithm (GA), simulated annealing (SA), immune algorithm (IA), water wave optimization (WWO), biogeography based optimization (BBO),particle swarm optimization (PSO),differential evolution (DE), teacher learning based optimization (TLBO), branch and bound method (B&B), ant colony optimization (ACO) and various others.The GA inspired and originated from the natural selection process, it is a meta-heuristic approach to produce high-quality results in order to achieve optimization by using a crossover, inversion, mutation and selection operators. GA is an approach to produce off-springs from the parent population called chromosomes, which consists of a gene. ACO is based on the ability of ants to find the shortest paths from their nest to food locations using pheromone trails. Thus, ACO algorithms solve the combinatorial optimization problems by mimicking real ants' behavior. The WWO was inspired by the shallow water wave theory, where the solution space is equivalent to the seabed area while the depth of seabed depth figures out the fitness of a point in the space. The meta-heuristic uses three operators: propagation creates high fitness waves that search small areas and low fitness waves that search large areas. The refraction operator enhances the diversity and thus decreasing premature convergence, and the Breaking operator is for intensively exploiting the local area around a promising point. The BBO is a bio-motivated and population-based optimization approach where the virtuousness of the habitat is measured by using (HSI). Suitability index variable (SIV) is used for characterizing the attributes of the natural habitat and expressed as one dimension in a solution. The algorithm entails two main operators, migration and mutation. The PSO is based on the observations of the social behaviors of bird flocking. The initial solutions are generated with a randomized velocity and new solutions are gained by competition and corporation between particles. The algorithms can be coded and executed with optimization software's. The software used for coding is selected so it is compatible, fast, and reliable with respect to the algorithm. Some frequently used software's are LINGO, MATLAB, CPLEX, GAMS, FORTRAN and languages for coding are java, C, C# and C++.

2. Literature review

A classical flowshop scheduling problem (FSP) under makespan criterion was studied [3]. Some new properties of problems related to blocks have been introduced that enable to avoid some non-perspective solution throughout the examination of the solution space. A Tabu search algorithm and some heuristics were proposed for the problem that produces optimal results when compared with other algorithms for large size problems.The multi-heuristic desirability ant colony system (MHD-ACS) heuristic for the non-permutation flowshop scheduling problem (FSP) with objective to reduce makespan [8]. The proposed MHD-ACS heuristic enhanced the quality of the upper bounds for the problem. The results of proposed heuristic were demonstrated and compared against other algorithms that were suitable for the problem.The FSP with blocking was addressed and three hybrid algorithms were proposed based on harmony search (HS) namely ashybrid harmony search(hHS), hybrid global-best harmony search(hgHS) and Hybrid Modified Global-Best Harmony Search(hmgHS) [5]. The primary goal of the research is to minimalize total flow time of jobs. The continuous harmony vector was converted in job permutation through the implementation of largest position value (LPV) rule. The NEH_WPT heuristic was introduced to generate higher quality initial harmony memory of algorithm and for the balancing

of global and local exploitations, the global search based on HS and insert neighborhood-based local search were hybridized. To well acquire great structures pitch adjustment rules were established for the global-best harmony vector. All the three hybrid algorithms with different pitch adjustment rules were represented. On the basis of experimental results, the hmgHS algorithm outperformed among the other two proposed algorithms hHS and hgHS. A novel bi-objective local search algorithm (BOLS) for hybrid flow shop scheduling problem under just in time environment [12]. The purpose of scheduling was to minimize bi-criteria objectives, total tardiness, and make-span.The BOLS algorithm developed with the combination of Local search method and Heuristics, where the local search included three stages. First stage assigned set of jobs are moved to other machines, the second stage changes the order of machines and third stage at the same time changes the order of jobs and job set of machines. The triangle method and hull approach verified the quality of solutions, and results were juxtaposed with multi-objective simulated annealing (MOSA) and bi-objective heuristic (BOH) approach. The presented method was applicable to find optimum solutions and to find Pareto frontier using other evolutionary algorithms.A self-guided differential evolution with neighborhood search, called (NS-SGDE) for solving the problem where 'n' jobs to be processed on 'm' machine with identical order permutation flowshop scheduling problem was developed [9]. The algorithm developed in three stages; Firstly, discrete harmony search(DHS) algorithm integrated with (NEH, Raj, FRB1) was proposed as an initial method for the NS-SGDE algorithm. Next, the probabilistic model of estimation of distribution algorithm (EDA) was used to generate the guided individual that was applied to guide the DE-based exploration. Some crossover and mutation operators like INSERT, SBOX, SJOX were used to obtain decent solutions. At last, the neighborhood search was constructed which is based on the variable neighborhood search (VNS) technique to improve the capabilities search and discovering optimal result. The Taguchi method of design of experiment was used to analyze the sensitivity of NS-SGDE parameters on its performance. The concurrence of NS-SGDE for permutation flowshop scheduling problemwas analyzed on the bases of the theory of Markov chain.The two-machines blocking flowshop scheduling problem with constraints like preemption and multi-task flexibility (mtflx) were studied [2]. The objective criteria was to minimize makespan, the mtflx was applicable only for the first machine, and this flexible machine was capable of processing various operations. Due to the NP-hard problem two mathematical models were developed that can find optimal results for the problem up to 22 jobs. Further, a VNS and its new variant called dynamic VNS (DVNS) were proposed for solving the problem for large instance. In the DVNS algorithm, for the shaking phase, it did not require any tuning of parameters like in VNS. The results validate the superiority of proposed algorithms as compared with other three well-known metaheuristics for the large size problems. The results also indicate that the DVNS algorithm performed much better than VNS.An average idle time (AIT) heuristic for no-wait flow shop production was proposed [7]. First of all, the present idle times and future idle times were considered, proposing an initial sequence algorithm, and then the insertion and neighborhood exchanging methods are to further improve solutions. The statistical tool ANOVA and paired t-test were used to verify the effectiveness of the AIT heuristic for large-scale instance based on average relative percentage deviation(ARPD). The ARPD, maximum percentage deviation (MPD), and percentage of the best solutions (PBS) are used to evaluate the effectiveness of each heuristic based on small and large-scale instances. The AIT heuristic based on 600 small-scale instances and 120 instances in Taillard's benchmarks, outperforms among the compared heuristics with the same computational complexity.A sub

population-based hybrid monkey search algorithm (HMSA) algorithm for FSP with makespan and total flowtime minimization as objective [10]. The problem was NP-hard and for both objectives, two different sub-populations were produced, and dispatching rules like shortest processing time (SPT) and longest processing time (LPT) incorporated with a constructive Nawaz–Enscore–Ham heuristic(NEH) heuristic was utilized to enhance the quality of solutions. Various algorithms such as hybrid genetic algorithm (HGA), improved iterated greedy algorithm (IIGA), ant colony optimization (ACO), particle swan optimization (PSO), artificial bee colony (ABC), iterated local search (ILS), multi-restart iterated local search (MRILS), differential evolution (DE) and VNS were used for the comparison of experimental results with the proposed algorithm. The results demonstrator the superior performance of the proposed HMSA algorithm among the other algorithms for makespan and total flowtime.A realistic hybrid flowshop problem for steelmaking continuous casting (SCC) production process which is fused with stage skipping and changeable processing time [14]. A new SCC model was developed to minimize makespan, waiting time and processing time. The GA was proposed which was enhanced with encoding methods, selection and crossover operators, along with quality improvement approach, elitist and restart strategy for solving the SCC model. For measuring the performance of algorithm ANOVA and Wilcoxon Signed Ranks test are carried out, also average relative percentage improvement (RPI) value and standard deviation are estimated.An enhanced migrating bird optimization (EMBO) algorithm and a new STH heuristic, for resolving the permuation flowshop scheduling (PFS) problem with sequence dependent setup times (SDST) was proposed target to decrease the makespan [4]. An adjusted neighborhood search method was utilized to upgraded the MBO based on the swap and forward addition moves. For improving the neighborhood search diversification, a tabu list was presented that is based on the same mechanisms as in tabu search metaheuristics. A circular tabu list containing swap and forward insertions was considered, to avoid premature convergence a restart mechanism was also introduced which is actually a quick path for expansion inside the EMBO. For answering the small, medium and large instances, the STH heuristic is quicker than the various existing heuristics. The results are evaluated using relative percentage deviation (RPD) and Student t-test, that shows both the algorithms are efficacious and efficient for resolving the problem.Two multi-objective optimizations namely multi-objective NEH algorithm (MONEH) and a modified multi-objective iterated greedy (MMOIG) algorithm were framed [16]. The energy saving method and accelerating methods were implemented in the extended NEH-Insertion Procedure for enhancing its effectiveness. The superior non-dominated results produced by the algorithms help to make a balance between the makespan and carbon emission. The addressed problem was permutation flowshop(PFS) scheduling where the carbon emissions and the makespan has to be minimized.The discrete water wave optimization(DWWO) algorithm for the no-wait FSP problem under makespan criterion [15]. In the normal water wave optimization (WWO) algorithm for improving the exploration ability, the iterated greedy (IG) algorithm was hired as propagation operator, crossover strategy as refraction operator that dodge algorithm dropping into local optima and insertion-based local search technique exploits as breaking operator that enhance the exploitation capacity of local search. The convergence speed of algorithm was enhanced by ruling out inferior solution operator and while convergence performance was analyzed through Markov model. The design of experiment(DOE) and ANOVA are utilized to tune the parameters of algorithms additionally, the ARPD and standard deviation (SD) values are used for the comparison of the proposed algorithm with state of the art algorithms.An enhanced hybrid genetic algorithm

(HGA) for investigating a specific Fuzzy Flowshop scheduling (FFS) problem with an SDST constraint was proposed [11]. The aim of the FFS problem is to reduce the energy consumption with respect to minimizing overall makespan and the tardiness between the jobs, this is achieved by determining optimal job sequences and state transition between machines. largest common pattern (LCP) scheme along with probabilistic heuristics were utilized to boost the evolution performance of the proposed GA algorithm.

Table 1: Review of Methods in Literature

Ref.	Methodology and Software	Input	Conclusion
[1]	Branch and boundalgorithm, FORTRAN	Two machines, numbers of jobs due dates, completion time	Two constructive heuristics (DC and DP) for large size problems
[6]	Heuristic based on Johnson's algorithm and SA, MATLAB, CPLEX	Number of jobs and machines, batches, processing time	Johnson's algorithm-based heuristic produce optimal results
[13]	Effective estimation of distribution algorithm (EDA)	Number of jobs,machines,completion andprocessing time	DPFSP problem and probabilitymodel and local search operator was designed
[17]	GA, MATLAB	Number of jobs, machines, completion and cutting parameters	FFS problem with energy consumption and makespan objectives

3.Advanced OptimizationAlgorithms for the multi-objective problems

In the hypothetical world of research, there are two sorts of problems, to be specified as single objective problems and multiple objective problems.In the scheduling problems,it consists anumber of objectives which has to be minimized for obtaining respectable results for the problems. The objectives like make-span, flow-time, tardiness, lateness, earliness, achieving due dates; decreasing job disruptions, energy consumption, scheduling costs etc.Now, a term called heuristic is characterized as an approach, which makes the on-looking problem easier, gives an answer, which might be correct or an estimated one. All the algorithms such as, GA, IA, SA, BBO, COA, PSO, WWO, TLBO, B&B, DE, ACO, ABC, VNS and various others are used for solving these multi-objective optimization problems, and able to produce optimal or near optimal results.

4.Challengesin the implementationof AdvancedAlgorithms

Asdevelopmentsare being made in every algorithm in almost every field they are used, still there stand some challenges to be uplifted.

(i) Problem Formulation: The problem formulation is a mainconstraintin the implementation of algorithms. The problem formulation is essential for obtaining optimal results. There is possibility of misinterpretation of the statistical information and mathematical formulas or relations used, which is to be avoided.

(ii)Computational Time: The formulation of results in a reasonable time is a decisive factor in selecting the algorithm. The complexity, number of iterations required and length of algorithm will drive the time factor. Further, the type and speed of processor used will affect the performance of algorithm.

(iii) Assumptions: The determination of assumptions should be made after studying the objectives, type of configuration, and with respect to the algorithm selected to solve the problem. There are numerous arrangements accessible, and all work with alternate points of view. The mechanism of the formulated algorithm is governed by the assumptions.

(iv)Quality of Solution: The quality of solutions produced is always under scrutiny. The algorithms must be modeled, keeping the optimal solutions in mind. The solution generated once, should require minimum optimization.

(v)The requirement for more relative information: It is hard to locate the ideal algorithms for specific problems as computational examinations made are just with a couple of techniques, rather should be improved the situation all the comprehensively arranged strategies. This makes it simple for the new scientist to pick either to change the less ideal one or pick the best to use with different parameters. A similar work won't be rehashed with other technique.

(vi) Tuning of parameters: The different parameters chose to be upgraded should be tuned with the chosen algorithms. There are numerous techniques accessible, for example, the design of experiments and analysis of variance to accomplish this. It is fundamental to choose the ideal parameters to upgrade the execution of the algorithm for a given situation.

5.Conclusion

The scheduling problems are the unavoidable ones, and in the present situation required to explain various goals, henceforth regularly known as NP-Hard problems, for each industry in the market. This paper conveys the utilizations of cutting edge algorithms in various production systems. The literature survey focusses on advanced algorithms with an objective such as minimizing the completion time, tardiness, earliness and so on. Various algorithms have been discussed which are applicable in solving small sized problems to large sized complex ones. These advanced algorithms are broadly utilized as a part of different field of sciences, such as computer, electronics, biology, mathematics etc. and in the various type of industries such as Aerospace, Automotive,Manufacturing, chemical etc. The variations and hybridization for more proficient and successful algorithms have dependably pulled in researchers and is a regarded territory of future research. There are a few difficulties that should be overcome to create more powerful and proficient arrangements.

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