International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 6 (2018) pp. 4282-4290

Nature inspired algorithms on Industrial applications: A survey

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Abstract

Soft computing based several techniques had already been applied previously in various industrial applications. This paper tries to provide in- depth study of all those happenings for various algorithms. The expected future needs of industry are based on proper application of these algorithms. A Novel merging of dissimilar methods is needed when developing high-performance, cost-effective, and safe products for the demanding global market. The Paper outlines comparative study of algorithms and objective functions of Soft Computing techniques for industrial applications.

Keywords: Job-shop scheduling, soft computing techniques, process planning, Machine Loading.

INTRODUCTION

1.1 Motivation: In the industrial world, it is general practice for companies to supply effective services for expensive machinery. Many manufacturing companies are moving their related operations to the service field where their expectation is to find higher margins. One application is the successful implementation of with service agreements and guaranteed up time. Because of unnecessary maintenance actions cost for given product can be increased, in the interest of maximizing the margins, service should only be performed when required. To achieve this, a tool can be proposed that measures the behavior of the system and provide results. Industrial applications consist of various problems that include job-shop scheduling, cost optimization, assembly line balancing optimization, process planning problem etc.

A. Job-shop scheduling: Job scheduling [1-5] contains objective for searching a particular order for the jobs processing on the machines so that values can be optimized. The values [6-10] used is the reduction of the peak make-span. Mathematical formulation varies from variants of job-shop scheduling problems [11-20]. One such formulation [4] is:

$C_{\max}(\pi) = C(J_n, m)$; Where π= $\{j_1, j_2,...,j_n\}$ represents a permutation, and $C(j_i, k)$ represents make-span [21-27] of job j_i on machine k.

$$C(Ji,1)=Pj_1,1; \quad (1)$$

$$C\left(J_1,k\right)=C\left(J_1,K-1\right)+P_{J_1,K} \ ; \quad (2)$$

Based on minimization of completion time [28-37] of various algorithms applied as per the above formulas a comparative study shows the best result.

B. Process planning problem: Process planning problem [38-44] is the reduction of production time (includes processing and transmission time).Mathematical formulation [44] can be like this:

$$PP = \left\{OP_1, OP_2,\ldots\ldots OP_n\right\} \ ; \quad (3)$$

OP_i is the i_{th} operation of the part. Where OPi is as following:

$$OP_i = \left\{OPT_{i1}, OPT_{i2},\ldots\ldots OPT_{im}\right\}; \quad (4)$$

$$OPT_{ij} = \left\{M_{ij}, T_{ij}, TAD_{ij}\right\} \ ; \quad (5)$$

C. Machine Loading problem: The loading problem [45-48] in industries relates with selecting a part of jobs from a collection of jobs to be produced and providing their functions to the specific machines with technological constraints to meet certain performance measure. Loading problem is to reduce the total system unbalance. Minimizing following equation [48] is based upon constraints that vary from problem to problem.

$$\sum_{m=1}^{M} Tm - \sum_{m=1}^{M}\sum_{j=1}^{J}\sum_{o=1}^{Oj} BjBjomXjom \quad (6)$$

LITERATURE GROUP AND ANALYSIS

Job-shop scheduling:

Scheduling problem is critically studied part in the industrial areas and used as a vital component in successful production planning and execution.

Ye Tian et al. [2012] proposed discrete PSO to unravel the two stage assembly scheduling problem based upon bicriteria of completion time and mean completion time, in which setup times and processing times are totally different to each other.

Amin Jamili et al. [2010] proposed PSO-SA related hybrid algorithm for periodic job shop scheduling problem.

Mohammad Mahdi Nasiri [2012] presented a pseudo PSO algorithm to unravel the Resource Constrained Project Scheduling Problem. The formulated algorithm applies path relinking procedure so that particles in PSO can fly toward local and global best positions. It is used for optimal make-span.

Bo Liu et al. [2006] proposed hybrid-algorithm, composed of PSO with Nawaz-Enscore-Ham heuristic and local search composed of SA along-with an adaptive metaLamarckian

learning strategy for no-wait-flow-shop scheduling in manufacturing industries.

Qiong Jia et al. [2013] proposed hybrid PSO for the resource-constrained-project-scheduling problem. It employed a double justification skill and move operator for the particles along with rank-priority-based representation, greedy random search, and serial scheduling scheme, for efficient solutions.

Liu Yongxian et al. [2008] proposed coding and optimized operation of PSO for job-shop scheduling.

Fuqing Zhao et al. [2015] proposed chemotaxis-enhanced bacterial foraging optimization to unravel the job shop scheduling problem for reducing make-span.

Chunguo Wu et al. [2007] proposed Bacterial Foraging Algorithm with an improved operation, individual-based search on job shop scheduling benchmark problems.

Hui Wang et al. [2016] proposed new cuckoo search to unravel flow shop scheduling problems using four different strategies. It is used to reduce the make-span.

Xiangtao Li et al. [2013] proposed cuckoo search based memetic algorithm, called Hybrid-Cuckoo-Search for permutation flow shop problem. This paper employs largest-ranked-value and Nawaz-Enscore-Ham to make a hybrid algorithm.

M.K. Marichelvam et al. [2016] presented hybrid harmonic search using SPV rule on multistage hybrid flow shop scheduling problems.

Rachhpal Singh [2016] proposed parallel job scheduling by applying hybrid Cuckoo Genetic Optimization Algorithm.

P. Ravichandran et al. [2016] proposed Hybrid CS-PSO on Parallel line job shop scheduling. It is used to reduce make-span.

Ali Al-maamari et al. [2015] proposed hybrid PSO with cuckoo search at parallel job scheduling on cloud environment to reduce make-span.

Tarun Kumar Ghosh et al. [2016] proposed a new algorithm for job scheduling using Genetic Algorithm and Cuckoo Search Algorithm for efficiently allocating jobs to resources in a Grid system so that make-span and flowtime are reduced.

Yu Jie Xiao et al. [2015] presented an iterated greedy based algorithm for integrated scheduling problem of machines and Automated Guided Vehicles in flexible manufacturing systems.

Walaa AbdElrouf et al. [2016] proposed a new job scheduling mechanism based on increasing the crossover rate in GA to reach the best solution faster to improve the functionality of the genetic algorithm.

K R Remesh Babu et al. [2016] proposed adjustment in the bee colony algorithm for proper load balancing in cloud environment.

Jindong Zhang et al. [2010] proposed circular discrete PSO algorithm which is presented to unravel the flow-shop-scheduling problem for reducing make-span.

Tianmin Zheng et al. [2010] presented a new quantum-differential-Evolutionary algorithm applied to the quantum-inspired evolutionary algorithm for permutation-flow-shop scheduling problem.

G.M. Komaki et al. [2017] proposed Improved Discrete version of Cuckoo Optimization Algorithm for three-stage assembly flow shop scheduling problem. Discrete version is used to reduce completion time of the make-span.

M. K. Marichelvam et al. [2016] proposed improved crow search algorithm to apply on single machine total weighted tardiness scheduling problems. It is used to calculate the computational times and a comparison is shown with other algorithms.

Hussin M. Alkhashai et al. [2016] proposed hybrid of the Particle Swarm Optimization, the Best–Fit, and Tabu-Search algorithms for task scheduling problem in a cloud environment. It is used to calculate execution time, cost, and resources utilization.

Weishi Shao et al. [2016] proposed self-guided differential evolution with neighborhood search for permutation flow shop scheduling problem. Its objective is to reduce the completion time.

Mehdi Akbari et al. [2016] proposed multi-objective scheduling cuckoo optimization algorithm for scheduling of tasks on heterogeneous systems. Its objective is to reduce the make-span.

Neenu George et al. [2016] proposed Cuckoo Search algorithm on task assignment to resources for optimizing computational cost.

Choo Jun Tan et al. [2013] presented modified micro genetic-algorithm for multiobjective problems in job-shop scheduling. It is used to maximize total cost saving and total earliness, minimizing the total tardiness.

Abdelhamid Bouzidi et al. [2017] presented a comparative study of three population-based metaheuristics for unraveling the Job-shop scheduling problem. They have taken cat swarm optimization algorithm, the Cuckoo search algorithm, and ant colony optimization to optimize total execution time.

Biao Zhang et al. [2017] presented effectual modified migrating birds' optimization for hybrid flowshop hybridizing with lot streaming to reduce total flow time. They have used shortest waiting time rule, combined neighborhood search strategy and Glover operator.

Debanjan Konar et al. [2017] presented an efficient real-time task scheduling assisted by Hybrid Quantum-Inspired Genetic Algorithm in multiprocessor environment. They have shown that hybrid algorithm shows better results than classical genetic algorithm and Hybrid PSO. To reduce completion time and determine optimal schedule earlier deadline first and shortest computation first was proposed.

Chao Lu et al. [2017] presented new multi-objective discrete virus optimization algorithm for flexible job shop scheduling problem with controllable processing times. Multi-objective discrete virus optimization algorithm with a three-part

representation for each virus and exploitation mechanism is deployed. It is used to reduce both the make-span and the total additional resource consumption.

Milica PETROVIĆ et al. [2016] presented Ant Lion Optimization for unraveling scheduling combinatorial optimization problem. It is used to show minimal production time.

Shashikant Burnwal et al. [2013] proposed cuckoo search algorithm with slight modification in its Levy flight operator containing 43 jobs and 16 machines. A comparative result was shown with a genetic algorithm.

Gai-Ge Wang et al. [2016] presented discrete krill herd for unraveling the flexible job-shop scheduling problem. Hybrid meta-heuristic cuckoo search and krill herds are applied and improvements are tested by 14 standard benchmarking functions.

Shivakumar B L et al. [2012] proposed hybrid harmony search with bacterial foraging applied on Job Shop Scheduling Problem. It is used to find best optimal cost.

Shengjun Xue et al. [2016] presented heuristic scheduling algorithm based on PSO in the cloud computing environment. It is used to reduce completion time and total cost.

Nima Jafari Navimipour et al. [2015] presented hybrid cuckoo search with an evolutionary algorithm on task scheduling. It is used to reduce execution time.

Table 1. For job scheduling problem

ARTICLE	ALGORITHM AND PROBLEM TYPE	OBJECTIVE FUNCTION
Ye Tian et al. (2012)	Discrete PSO for hybrid assembly scheduling problem	To reduce mean completion time
Amin Jamili et al. (2010)	PSO-SA based hybrid algorithm for periodic job shop scheduling	Reduce the completion time of all jobs.
Mohammad Mahdi Nasiri (2012)	Pseudo PSO for Resource Constrained Project Scheduling Problem	For optimal make-span.
Bo Liu et al. (2006)	Particle swarm optimization with Nawaz Enscore-Ham for no-wait flow shop scheduling	To compare time performances of various approaches.
Qiong Jia et al. (2013)	New PSO for constrained project scheduling problem	To reduce make-span.
Liu Yongxian et al. (2008)	PSO for jobshop scheduling	To reduce the maximal finished time.
Fuqing Zhao et al. (2015)	Chemotaxis-enhanced bacterial foraging optimization for job-shop-scheduling problem	To reduce the total make-span time.
Chunguo Wu et al. (2007)	Bacterial foraging algorithm for job shop scheduling benchmark problems	To reduce make-span
Hui Wang et al. (2016)	New cuckoo search for solving flow shop scheduling problems	To reduce make-span
Xiangtao Li et al. (2013)	Cuckoo search memetic algorithm for permutation flow shop problem	Minimizing make-span.
M.K. Marichelvam et al. (2016)	Hybrid harmonic search for multistage hybrid flow shop scheduling	To reduce the make-span
Rachhpal Singh (2016)	Hybrid Cuckoo Genetic Algorithm for parallel job scheduling	To reduce the completion time and load balancing of resources
P. Ravichandran et al. (2016)	Hybrid CS-PSO on Parallel line job shop scheduling	To reduce completion time.
Ali Al-maamari et al. (2015)	Hybrid PSO with cuckoo search at parallel job scheduling	Reduced make-span and maximizing the resource utilization
Tarun Kumar Ghosh et al. (2016)	Hybrid algorithm based on GA and cuckoo for job scheduling	To reduce completion time
Yu Jie Xiao et al. (2015)	Hybrid iterated greedy based algorithm for integrated scheduling problem	For minimizing the make-span.
Walaa AbdElrouf et al. (2016)	Increased crossover rate in genetic algorithm for scheduling problem	To reduce the finish time
K R Remesh Babu et al. (2016)	Hybrid bee colony algorithm for cloud environment	For improved load bal.ancing
Jindong Zhang et al. (2010)	Circular hybrid PSO for flow shop scheduling problem	Reducing make-span.

Tianmin Zheng et al. (2011)	Quantum- differential-evolutionary algorithm for permutation-flow–shop-scheduling problem.	Reduce make-span, Average convergence generation, Average computation time, Relative error.
G.M. Komaki et al. (2017)	Improved Discrete version of Cuckoo Optimization Algorithm for three stage assembly flow shop scheduling problem	Reduce completion time.
M. K. Marichelvam et al. (2016)	Improved crow search algorithm applied on scheduling problems of single machine total weighted tardiness	Calculate the computational times
Hussin M. Alkhashai et al. (2016)	Hybrid of the Particle Swarm Optimization, the Best Fit, and Tabu Search algorithms for task scheduling problem	Calculate execution time (Make-span), cost, and resources utilization
Weishi Shao et al. (2016)	Hybrid self-guided differential evolution with neighborhood search for permutation flow shop scheduling problem	Reduce the completion time
Mehdi Akbari et al. (2016)	Multi objective scheduling new cuckoo optimization algorithm for scheduling of tasks on heterogeneous systems	Reduce the make-span
Neenu George et al. (2016)	Cuckoo Search algorithm on task assignment to resources	Optimizing computational cost
Choo Jun Tan et al. (2013)	New micro-genetic-algorithm for multi- objective-optimization problems in job-shop scheduling	Maximize total cost saving and total earliness, minimizing the total tardiness.
Abdelhamid Bouzidi et al. (2017)	Cat swarm optimization algorithm, Cuckoo search algorithm and ACO for Job-shop scheduling problem	Optimize total execution time.
Biao Zhang et al. (2017)	Modified migrating birds optimization for hybrid flowshop	Reduce total flow time
Debanjan Konar et al. (2017)	Hybrid Quantum based GA for real-time task scheduling	To reduce completion time and to determine optimal schedule
Chao Lu et al. (2017)	Multi-objective discrete virus optimization algorithm for flexible job-shop scheduling problem	Minimizing both the make-span and the total additional resource consumption
Milica PETROVIĆ et al. (2016)	Ant Lion Optimization to unravel scheduling combinatorial optimization problem	Minimal production time
Shashikant Burnwal et al. (2013)	cuckoo search algorithm with slight modification in its Levy flight operator for scheduling problem	To reduce final penalty cost and maximizing machine utilization time.
Gai-Ge Wang et al. (2016)	Discrete krill herd to unravel scheduling problem	Optimizing computation time
Shivakumar B L et al. (2012)	Hybrid of harmony and bacterial foraging on flow shop scheduling problem	To find best optimal cost.
Shengjun Xue et al. (2016)	Hybrid PSO algorithm for scheduling problem	Reduces completion time and cost of task
Nima Jafari Navimipour et al. (2015)	Hybrid cuckoo search algorithm for task scheduling	To reduce execution time

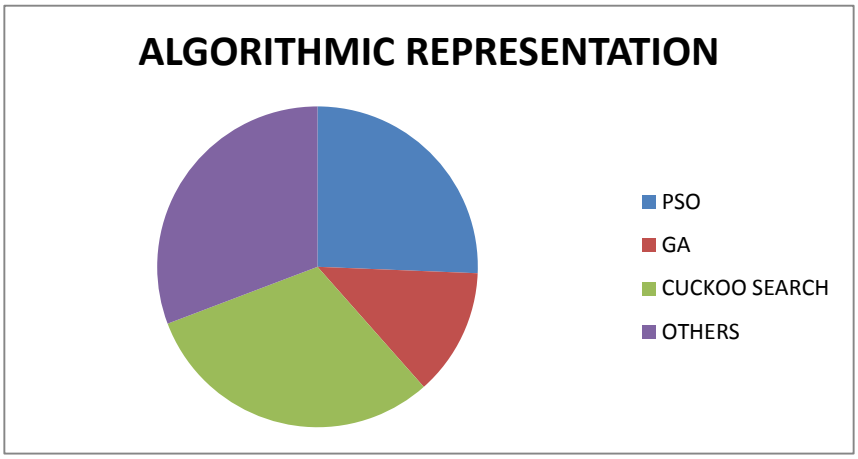

Figure 1: Various algorithms representation for scheduling problems.
Pie chart reflects various algorithms used on the scheduling problems.

Process planning:

Process planning problem [38-44] is a combinatorial Optimization problem to apply operations selection and sequencing simultaneously with various constraints in the modern manufacturing system.

Milica PETROVIĆ et al. [2016] presented Ant Lion Optimization for solving Process planning problem. It is used to show minimal Production time.

Xinyu Li et al. [2013] presented a new PSO algorithm to optimize the process planning problem. They have developed efficient encoding, updating, and random search methods.

HongGuang Lv et al. [2009] proposed a discrete version of PSO algorithm to unravel the assembly sequence planning problem.

Wenbin Xie et al. [2014] presented a tool based on GA that finds balance among various factors for production problems. The tool was applied to various production problems to test various factors.

Ahmed T. Saadeq Al-Obaidi et al. [2016] proposed two different algorithms based on Cuckoo Search for solving the flexible scheduling problem. These are used to increase the solution quality and convergence rate.

Hongyan Cui et al. [2017] presented Genetic Algorithm-Chaos Ant Colony Optimization to unravel task scheduling by taking a weighted sum of make-span and flowtime as the objective function.

Song Huang et al. [2016] proposed a new version of hybrid PSO to unravel flexible scheduling problem with fuzzy processing time.

Jinfeng wang et al. [2015] presented Hybrid Bat Algorithm for Process Planning Problem. It is used to unravel process planning problem.

Table 2. For Process planning problem

ARTICLE	ALGORITHM AND PROBLEM TYPE	OBJECTIVE FUNCTION
Milica PETROVIĆ et al. (2016)	Ant Lion Optimization for solving Process planning problem	Minimal production time
Xinyu Li et al. (2013)	New PSO for process planning problem	To optimize the process planning problem
HongGuang Lv et al. (2009)	Hybrid algorithm of PSO to unravel assembly sequence planning problem	To optimize assembly Sequence
Wenbin Xie et al. (2014)	Genetic algorithm tool for various production problems	Total idle time of machines, work-in-process inventory, delivery performance
Ahmed T. Saadeq Al-Obaidi et al. (2016)	Cuckoo Search to unravel Flexible Job-Shop Scheduling problem	To increase solutions' quality and convergence rate.
Hongyan Cui et al. (2017)	Genetic Algorithm-Chaos Ant Colony Optimization for task Scheduling	For weighted sum of make-span and flowtime
Song Huang et al. (2016)	New version of hybrid particle-swarm- optimization to unravel flexible-job-shop scheduling problem	To reduce the maximal fuzzy make-span
Jinfeng wang et al. (2015)	Hybrid Bat Algorithm for Process Planning Problem	To unravel process planning problem

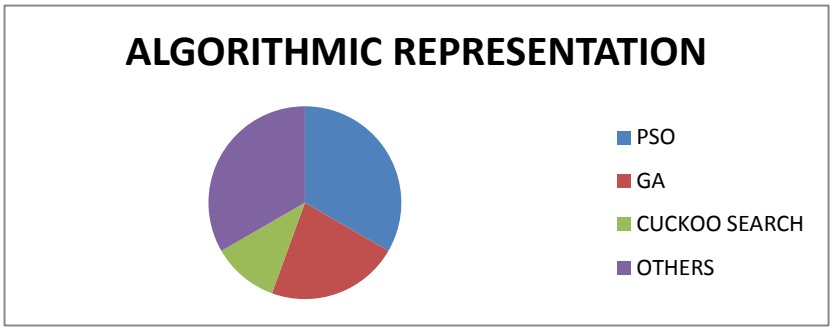

Figure 2: various algorithms representation for Process planning problem.

Pie chart reflects various algorithms used on the Process planning problems.

Machine load problem:

Mir Saber Salehi Mir et al. [2016] presented new algorithm PSO combined with GA for unrelated parallel machines scheduling problem with various factors on each machine

R. SundarRajan et al. [2016] employed Firefly algorithm to schedule the jobs and thereby evenly distribute the load and in turn reduce the overall completion time.

Eleonora Bottani et al. [2017] proposed modified discrete firefly algorithm (DFA) applied to the machine loading problem of the flexible manufacturing systems. It is used to identify the optimal jobs sequence, increasing throughput and reduces the balancing problem.

Sandhyarani Biswas et al. [2007] presented hybrid PSO using modified mutation operator on Flexible manufacturing systems. It is used to reduce the system unbalance.

Table 3. For machine loading problem

ARTICLE	ALGORITHM AND PROBLEM TYPE	OBJECTIVE FUNCTION
Mir Saber Salehi Mir et al. (2016)	New hybrid particle-swarm with genetic applied on unrelated-parallel machine-scheduling problem	To reduce total make-span and machine load
R. SundarRajan et al. (2016)	Firefly algorithm for scheduling of jobs	To reduce the overall completion time by evenly distributing the load.
Eleonora Bottani et al. (2017)	Modified discrete firefly algorithm for machine loading problem of the flexible manufacturing systems	To increase throughput and reduces the system unbalance.
Sandhyarani Biswas et al. (2007)	Hybrid PSO using modified mutation operator on Flexible manufacturing systems	To reduce the system unbalance.

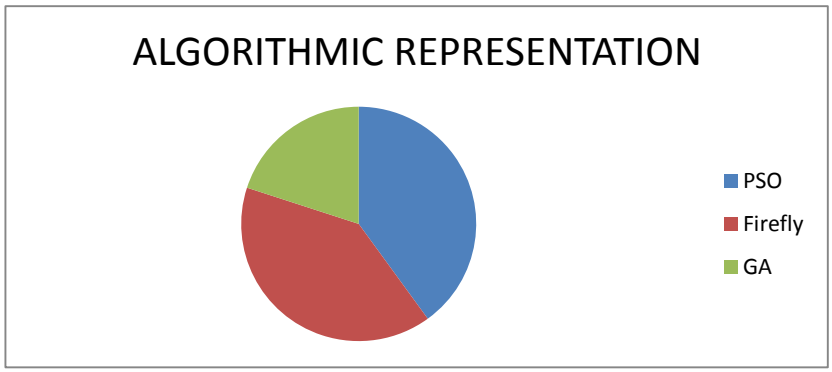

Fig. 3: various algorithms representation for machine loading problem
Pie chart reflects various algorithms used on the machine loading problem.

CONCLUSION

This paper surveyed the job shop related current research papers in context with scheduling, process planning and loading problems. This paper also converges to the algorithmic approach that is applied on variants of multi-objective problems. Survey analyses about papers based upon various parameters, making a current comparative analysis of objective functions so that various methods can be studied. Researchers can take help from survey to analyze the current algorithms and improvement in various fields that can be applied. By studying various objective functions researchers can apply hybrid development to industry applications.

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