Brazilian Journal of Systems Analysis, Modeling and Optimization manuscript No.
(will be inserted by the editor)

Similar Particle Collision for the Job Shop Scheduling Problem

Tatiana Balbi Fraga[1], **Antonio Jose da Silva Neto**[2*]

[1] Centro Acadêmico do Agreste / Universidade Federal de Pernambuco

[2] Instituto Politécno do Rio de Janeiro / Universidade Estadual do Rio de Janeiro

Received: date / Revised version: date

Abstract In this paper we present the Similar Particle Collision heuristic (SPC) and the Similar Particle Multicollision algorithm with Exploration by Tabu Search, specially developed to solve the Job Shop Scheduling Problem. Although there is a wide range of heuristics and algorithms developed to solve this famous problem, the SPC has an interesting characteristic, since its application is not very sensitive to the adjustment of the parameters used. Another important characteristic is that the presented heuristic allows the successful hybridization of different algorithms mixing aspects of local and global exploration. As we can see, the results are as good as the best results presented in the literature and the method attenuates the different results found by adjusting the parameters, leading to a more robust search.

Send offprint requests to:

* *Present address:* Insert the address here if needed

1 Introduction

Talk about heuristics for combinatorial optimizatiom problem and hibridization.

1.1 Job Shop Scheduling Problem

Present the Job Shop Scheduling problem. Lecture on the algorithms applied to solve the problem and in particular on hybrid algorithms.

1.2 Particle Collision method

By observing the physics of the collision process between nuclear particles inside a nuclear power reactor it is possible to verify that, among the colliding particles, those that reach the nuclei, i.e. regions of high fitness, are absorbed and explore the surroundings while that those that reach regions of low fitness can be absorbed or spread to other regions according to some probability function. Analyzing these interactions, Sacco and Oliveira (2005) observed that the succession of absorption and scattering events allowed the movement of particles to promote an exploration of the complete search space while a deeper exploration of the most promising areas. Thus, based on this observation, the authors proposed a new algorithm for search which they named the Particles Collision Algorithm. In this algorithm initially a solution is chosen and reserved as current solution. Then, this current solution is perturbed through a perturbation() function, generating a new solution. If the new solution is "better" than the current solution (according to some previously defined criteria - evalFunction()), the last solution is replaced by the first and on this a local search procedure defined by an exploitation() function is applied. If the new solution is "worse" than the current solution, then a function scattering() is applied, where a probability function is used to define whether the current solution will be explored or replaced by a random solution. Note that this algorithm has a similar structure to Simulated Annealing except for the fact that the algorithm can be taken to new search spaces not directly related to the initial solution. Additionally, it is not necessary to define an initial temperature. Alg. 1 presents a pseudo-code for the PCA, as proposed by Sacco et al. (2006) for solving continuous maximization problems. Note that the function of probability is defined by the criterion of Metropolis (METROPOLIS et al., 1953).

applied in the same algorithm. In these figures it is possible to observe that, when working with continuous variable problems, perturbations are generated through variations random changes in the value of each variable within previously established limits, with the small perturbations similar to the perturbations, differing only in the limits that are more narrow. In the case of discrete problems like PEPOM, it is necessary to define how these disturbances will take place.

Than inform what subject is discussed in this paper and highlight the innovative aspects of the work

```
input  : initialSolution, evalFitness()
output: betterSolution, fitnessBetter

betterSolution ← currentSolution ← initialSolution;
fitnessBetter ← fitnessCurrent ← evalFitness(currentSolution);
for n ← 1 to NIte do
    newSolution ← pertubation(currentSolution);
    fitnessNew ← evalFitness(newSolution);
    if fitnessNew > fitnessCurrent then
        currentSolution ← exploitation(newSolution);
    else
        currentSolution ← scattering(newSolution);
    end
    fitnessCurrent ← evalFitness(currentSolution);
    if fitnessCurrent > fitnessBetter then
        betterSolution ← currentSolution;
        fitnessBetter ← fitnessCurrent;
    end
end
```

Algorithm 1: Particle Collison Algorithm

2 Similar Particle Collision heuristic

In Similar Particle Collision heuristic (Fig. 1) the functions, Disturbance() and Exploit() are respectively replaced by operators of Disturbance and Local Exploration. As Disturbance operators, whose purpose is to take the algorithm to new search spaces, we sugest mutation operators used in Genetic Algorithms, such as the operators M1 to M10 presented by Lian et al. (2006). Alternatively, if the Similar Particle Collision algorithm is applied simultaneously to all individuals of an initial population, we sugest crossover operators used in Genetic Algorithms, applied on pairs of solutions, such as the operators C1 to C4 also presented by Lian et al. (2006). In the case of Local Exploration operators, whose purpose is to explore the surroundings of a given solution, we suggest the various local search algorithms built based on heuristics such as Simulated Annealing, Genetic Algorithms, Particle Collision and Tabu Search.

3 Similar Particle Multicollision algorithm with Exploration by Tabu Search

Include explanation about the algorithm and [1]

4 Tests and results

??.

5 Conclusions and future work

References

1. Author, Journal **Volume,** (year) page numbers.
2. Author, *Book title* (Publisher, place year) page numbers

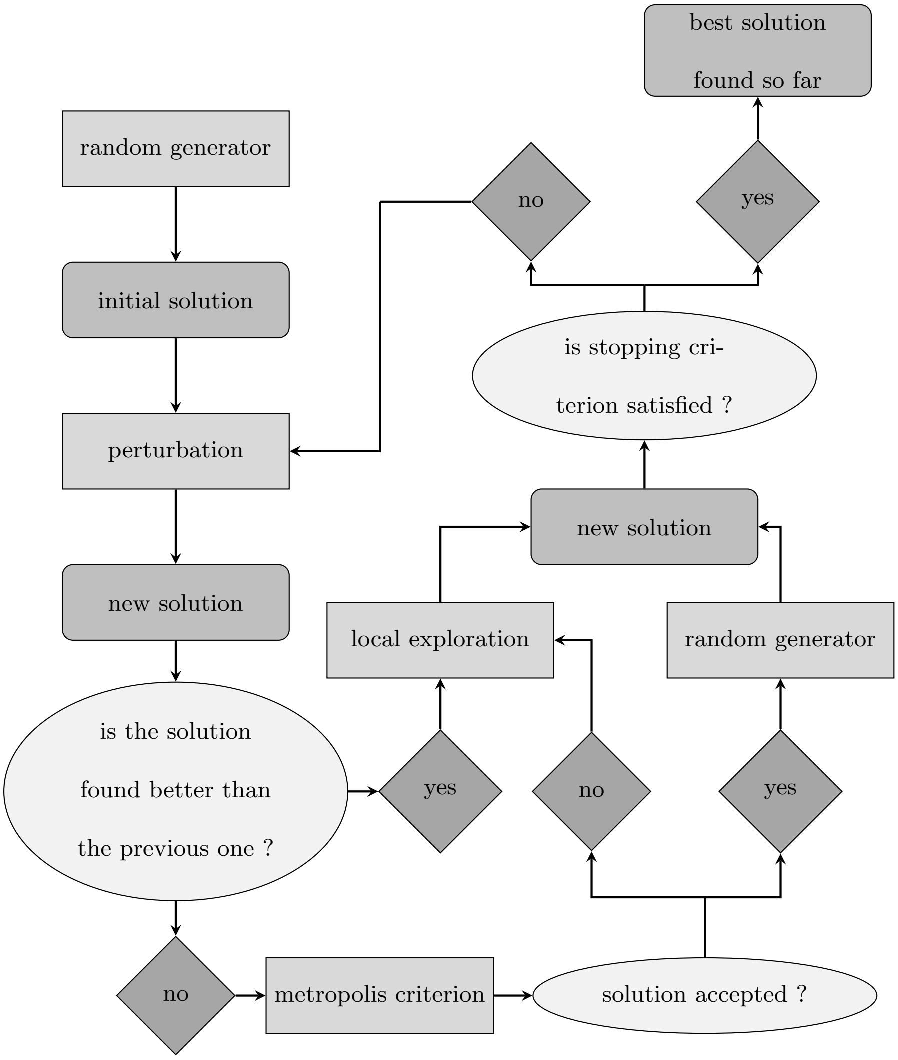

Fig. 1 Particle Collision Heuristic.

Fig. 2 Please write your figure caption here

Fig. 3 Please write your figure caption here

Table 1 Please write your table caption here

first	second	third
number	number	number
number	number	number