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A Survey on Parallel Evolutionary Computing and Introduce Four General Frameworks to Parallelize All EC Algorithms and Create New Operation for Migration

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Abstract. Optimization and solving NP-hard problems are very important and Evolutionary Computing (EC) methods are useful and popular. There are different types of EC methods that most of them are sequential and some others have parallel implementation. In first step we want to review some parallel implementation of EC methods and in second step we introduce four general frameworks to parallelize all EC algorithms that they are Master-Slave method, Hybrid method, Simple Multi-population method and Repulsive Multi-Population method. Finally we create a new operation for migration to keep population diversity.

Keywords: parallel genetic algorithms, parallel PSO, parallel ant colony optimization, parallel bee colony optimization, parallel memetic algorithm, repulsive operation.

1. Introduction

Optimization algorithms can be classified in heuristic and Meta heuristic. In the class of heuristic algorithms, there are construction and improvement algorithms. Meta heuristic algorithms may manage a chain or flow of executions of classical heuristics, e.g. Tabu Search, Simulated Annealing, Genetic and Memetic Algorithms.

Computability is a big problem for researchers and some problems such as NP-Hard problems have not a suitable solution that finds the best answer in limited time. There are different methods to solve them but EC are the best and more popular than them. There are different types of EC that are useful for different problems, for example Genetic algorithms are an old method for discrete problems and utilize some regular behavior in humans body and some characteristics of them and help researchers that optimize their solutions. The other one is PSO that mimics behavior of birds when migrate to other place.

EC methods are successful to solve different problems but there are some weak points that are the important reasons of bad results. For example in some problems that have a big search space is impossible that algorithms converge to local optimum results and we can improve results only with increasing of initial population. The other problem is the speed of algorithms and sometimes answers are found after a long time. Parallel algorithms can help us to improved quality and times of results.

In the past years researchers utilized some parallel EC methods to obtain good results, e.g. Parallel Genetic Algorithms [3], Parallel PSO [6], Parallel ABC (PABC) [5], Parallel Ant Colony Optimization (PACO)[4] and Parallel Memetic[7] that are more popular than other methods. Each one implemented with different technique and different equipment and hardware. For example Parallel Genetic Algorithms implement in four categories [3]: Master-Slave Genetic Algorithms, Corse Grain Genetic Algorithms (Multi-Populations Genetic Algorithms), Fine Grain Genetic Algorithms and Hybrid Genetic Algorithms that we will discuss about them in the next section.

There are different EC methods but some of them have not parallel implementation, for example ICA is a new and efficient method that is useful for continuous problems. In this Article we want to introduce four general frameworks to parallelize all EC algorithms. They divide on four categories: the first method is Master-Slave and try to decrease run time of algorithm, the second method is Hybrid method that is more complex and faster than other categories. The third method is Simple Multi-Population that is more popular and easier than others and fourth method is Repulsive Multi-Population.

2. Pervious and Related Works

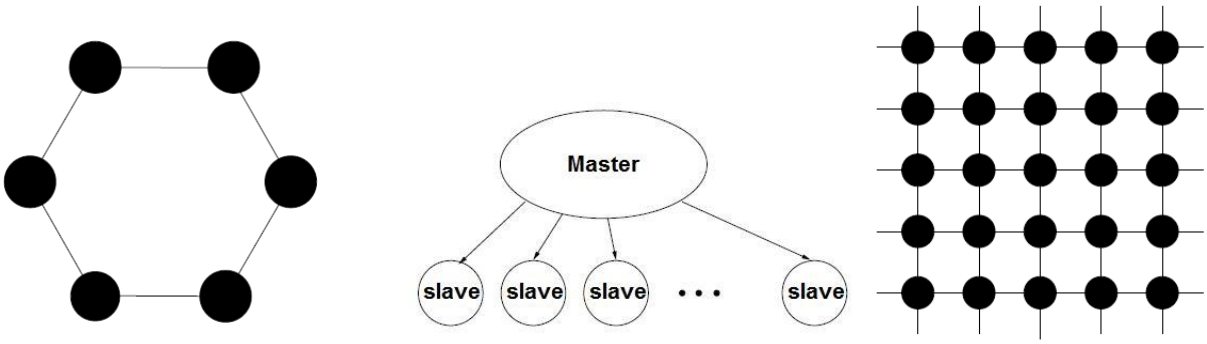
In this section we will review some parallel EC methods and try to find some common characteristic between them and utilize some of them in our implementation.

2.1. Parallel Genetic Algorithms

Genetic algorithms are population base methods that use some regular behavior of human body; each GA has an initial population and does some operations frequently that are selection, crossover, mutation and replacement. All operations are repeated until give a good result or end certain generation. A GA finds a good result when have a good selection pressure, so multi-population methods are useful because we could have bigger memory with using several processors and their memories. In multi-population methods there are several processors an each one have independent populations and each processor runs a simple GA, after certain generations all processor will stop and send some chromosome (Migration) with certain strategy, e.g. best or worse, and share results of solutions together. In this method there are some important parameters, migration rate, migration gap, topologies. Master-Slave method is the other methods.

In Master-Salve one processor is master and does all important operations of GAs such as crossover, mutation, replacement and selection and the other processor that called slave only evaluates fitness function and send back results to master processor. These methods can be implemented as synchronous and asynchronous. Synchronous methods behavior is same as simple GAs but with better runtime.

Fine grain are suitable method for parallel computing with massive processors and each processor can communicates to neighborhood processors and each individual can recombines with each individual on neighborhood processors. Speed of this methods are good but is not economical.



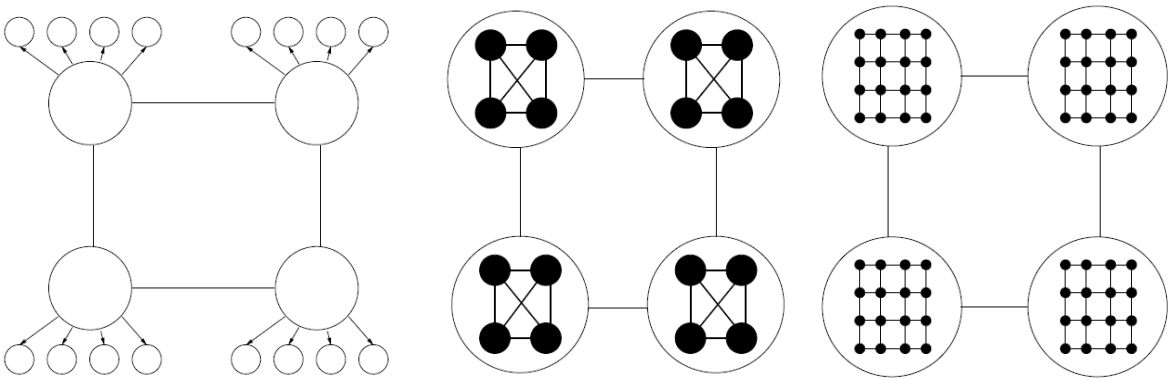
(a) (b) (c)

Fig 1: (a) Multi-population schema (b) Master-Slave schema (c) Fine grain schema [3].

Hybrid GAs are compound methods and create from two levels, upper level uses multi-population method and in lower level utilize each one of multi-population or master-slave or fine grain. This method is more efficient and faster than other methods because in this method we utilize capability of each method alone.

2.2. Parallel Ant Colony Optimization

Now we want to have a review on parallel ACO categories. ACO is an evolutionary algorithm that mimics behavior of ant to find destination. Ants use pheromone to select shortest way to find food. There are two important methods to implement parallel ACO, the first one is PACO and other one is PACO-CGD.



(a) (b) (b)

Fig 2: (a) Hybrid schema (high level is multi-population and low level is master-slave) (b) Hybrid schema (high level and low level are multi-population) (c) Hybrid schema (high level is multi-population and low level is fine grain) [3].