The GASAT Solver

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1 Introduction

We are interested in the development of incomplete algorithms based on a hybrid approach which combines local search [8] and genetic algorithms [3]. Indeed, this general Genetic Local Search approach has proven to be quite successful in recent years in solving a number of well-known difficult problems such as the traveling salesman problem [7] and the graph coloring problem [2]. The main motivation behind this approach is to use recombination (crossover) as a guided diversification mechanism and local search as a powerful intensification mechanism. A first genetic local search algorithm for SAT was reported in [1] leading to remarkable results.

Until now, specific crossover operators have not been deeply studied for the SAT problem [1, 6]. We follow the genetic local search schema and focus on the design and study of a hybrid algorithm based on SAT specific crossover operators combined with Tabu Search (TS). The resulting algorithm is called GASAT [4] (Genetic Algorithm for SAT). Within GASAT, specific crossover operators are used to identify particularly promising search areas while TS performs an intensified search of solutions around these areas. Therefore, we hope to be able to achieve a good compromise between intensification and diversification in the search procedure. A key point of this hybrid algorithm is obviously the definition of the specific crossover operator which should take into account the semantic meaning of the SAT problem.

2 The GASAT Algorithm

Given an initial population where each individual represents a truth assignment, the first step consists in selecting its best individuals w.r.t. a fitness function corresponding to the number of unsatisfied clauses. Then, two individuals (parents) are randomly selected and recombined by the CC crossover [5] to obtain a new individual (child). This resulting child is improved using the TS procedure and then added to the current population under particular insertion conditions. This whole process is repeated until a solution is found or until a fixed maximum number of crossovers is reached. The pseudo-code of the GASAT algorithm is described in algorithm 1.

GASAT introduces two mechanisms to manage its population of individuals. First, a specific selection of the parents helps the crossover to produce a good child and ensures the diversity of the selected parents. Second, the children are only introduced in the population under certain insertion conditions. This mechanism acts as an intensification process by drawing aside bad individuals.

The selection operator is a function $select\colon 2^{\mathcal{S}} \times I\!N \rightarrow 2^{\mathcal{S}}$ which takes as input a given population and extracts a sub-population which will serve as parents for the recombination stage. To insure an efficient search, it is necessary to keep some diversity (according to an entropy criterion) in the population. Indeed, if the selected parents are too similar, some region of the search space $\mathcal{S}$ may not be explored.

A child can be inserted according to different conditions (e.g. if it is better than any individ-

Data : a set of CNF clauses ϕ, $Maxflip$, $MaxNbCross$
Result: the best truth assignment
begin
  CreatePopulation(P);
  $NbCross \leftarrow 0$;
  while *no* $X \in P$ *satisfies* ϕ *and* $NbCross < MaxNbCross$ **do**
    /* Selection */;
    $P' \leftarrow Select(P, n)$;
    Choose $X, Y \in P'$;
    /* Crossover */;
    $Z \leftarrow crossover(X, Y)$;
    /* TS improvement */;
    $Z \leftarrow Tabu(Z)$;
    /* Insertion condition of the child */;
    Insert Z in P under insertion condition;
    $NbCross \leftarrow NbCross + 1$;
  end
  if *there exists* $X \in P$ *satisfying* ϕ **then**
    return the corresponding assignment
  else
    return the best assignment found
  end
end

Algorithm 1: GASAT Algorithm

ual of the population). These conditions are important with respect to the average quality and the diversity of the population. In the GASAT algorithm, a child is inserted if its fitness function is better than the fitness function of the worst individual of the current sub-population of selected potential parents P'.

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