A General Purpose Local Search Solver

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Description

The field of optimization can be split into several subfields depending on the nature of the decision variables (continuous, discrete) and the structure of the problem (linear, non linear, combinatorial, convex, non convex). The main focus of this thesis is discrete optimization both linear and non linear. Several solvers are available for discrete optimization. The mixed integer linear programming (MILP) approach has solver such as GLPK, Gurobi and CPLEX. There are also constraint programming (CP) solvers, such as Gecode. All these solvers solve the problem exactly but that is not always possible due to the computational cost of the problem. Another approach is to use local search and try to find a good solution fast by making a trade off between speed and solution quality. There exists a vast literature about how to make good local search solvers for specific problems.

However only a few attempts have been made to use local search for general purpose nature of solver like mathematical programming and Constraint programming. Comet was a successful CP based solver and takes advantage of local search to find a good solution fast but the project is now abandoned. Currently LocalSolver is a commercial product that combines local search with a modeling language. It can be used to solve mathematical, constraint, continuous, and non linear programming.

In this project, a general heuristic solver based on local search will be developed. Initially, it will be a solver for problems formulated as binary programming problems. For the part of software engineering we will combine ideas from Comet, LocalSolver, Gecode and Easylocal which is a local search framework.

Beside the basic components of local search there are several elements that will be studied to improve the solver. One of these elements is preprocessing that can reduce the size of the search space before the local search is started and improve the speed of the solver considerably. Other elements that will be studied are invariants and directed acyclic graphs (DAGs) to represent efficiently the dependencies between the variables. The choice of neighborhoods and how to efficiently explore these neighborhoods also be considered. Finally, on top of the local search there several metaheuristics that can be studied.

The goal will then be to extend the range of problems that can be solved by looking at more general, non linear constraints such as those considered in CP.

The performance of the solver will be tested with the instances from the MIPLIB, on timetabling problems and eventually on some competitions like the International Nurse Rostering Competition (NERC) and the MiniZinc challenge.