Abstract

Automatic recognition of objects in images is a difficult and challenging task in computer vision which has been tackled in many different ways. Based on the powerful and widely used concept to represent objects and scenes as relational structures, the problem of graph matching, i.e. to find correspondences between two graphs is a part of the object recognition problem. Belonging to the field of combinatorial optimization graph matching is considered to be one of the most complex problems in computer vision: It is known to be NP-complete in the general case.

In this thesis, two novel approaches to the graph matching problem are proposed and investigated. They are based on recent progress in the mathematical literature on convex programming. Starting out from describing the desired matchings by suitable objective functions in terms of binary variables, relaxations of combinatorial constraints and an adequate adaption of the objective function lead to continuous convex optimization problems which can be solved without parameter tuning and in polynomial time. A subsequent post-processing step results in feasible, sub-optimal combinatorial solutions to the original decision problem.

In the first part of this thesis, the connection between specific graph-matching problems and the quadratic assignment problem is explored. In this case, the convex relaxation leads to a convex quadratic program, which is combined with a linear program for post-processing. Conditions under which the quadratic assignment representation is adequate from the computer vision point of view are investigated, along with attempts to relax these conditions by modifying the approach accordingly.

The second part of this work focuses directly on the matching of subgraphs – representing a model – to a considerably larger scene graph. A bipartite matching is extended with a quadratic regularization term to take into account relations within each set of vertices. Based on this convex relaxation, post-processing and the application to computer vision are investigated and discussed.

Numerical experiments reveal both the power and the limitations of the approach. For problems of sizes which occur in applications the approach is quite reasonable and often the combinatorial optimal solution is found. For larger instances the intrinsic combinatorial nature of the problem comes out and leads to sub-optimal solutions which, however, are still good.