A Novel Practical and Fast Economic Method Based on Nonconvex Quadratic Programming

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Abstract: In many industries such as power system, economic operations problems are usually nonconvex problems that are hard to be solved. This paper presents a novel YALMIP-based nonconvex quadratic programming model as a tool to find solution for which is accurate, and there is no need to convexify the problem. In the end, the effectiveness of the method is shown by applying it to nonconvex problems.

I. Introduction

Recently, optimization problems have gained considerable attention [1-7] since they offer significant advantages such as economic benefits, reliability enhancement, environmental benefits, etc. [8-14]. In different fields in engineering which huge parameters are involved, selecting precise methods of optimization which can comprehensively analyze the process find momentous role[my references:[15-16]. However, the main problem that matters is that most of the optimization problems are non-convex and nonlinear and therefore are very hard to solve [17-19]. Even when solved, the optimality of the solution is not reliable enough [20-22]. The main reason for that is the linearization process applied on the formulations for approximation of the results and often there will be error between the linearized and nonlinear/nonconvex model [23-27].

There are several solver and software packages as tools of finding solutions for nonconvex problems. YALMIP is one of the fast and accurate Matlab based software for dealing with such problems [27-30]. It is widely used in many fields of sciences, engineering, geoscience, math, etc. [31-33]. This paper investigates the capabilities of this technique in solving nonconvex problems. Section II of the paper presents the semidefinite relaxation code of the YALMIP and section III demonstrates simulation results. Finally, section IV presents conclusion.

II. Semidefinite Relaxation

This section presents the code of this technique [34].

```
Q = magic(5);
x = sdpvar(5,1);
optimize([-1 <= x <= 1],x'*Q*x)
X = sdpvar(5);
optimize([-1 <= x <= 1, X == x*x'],trace(Q*X))
X = sdpvar(5);
optimize([-1 <= x <= 1, [1 x';x X]>=0, rank([1 x';x X])==1],trace(Q*X))
X = sdpvar(5);
optimize([-1 <= x <= 1, [1 x';x X]>=0],trace(Q*X))
sol = optimize([-1 <= x <= 1],x'*Q*x,sdpsettings('solver','moment'));
sol = solvemoment([-1 <= x <= 1],x'*Q*x);
ops = sdpsettings('solver','moment','moment.order',2)
sol = optimize([-1 <= x <= 1],x'*Q*x,ops)
ops = sdpsettings('solver','moment','moment.order',3)
sol = optimize([-1 <= x <= 1],x'*Q*x,ops)
relaxvalue(x'*Q*x)
value(x'*Q*x)
assign(x,sol.xoptimal{1})
value(x'*Q*x)
assign(x,sol.xoptimal{2})
value(x'*Q*x)
ops = sdpsettings('solver','bmibnb')
sol = optimize([-1 <= x <= 1],x'*Q*x,ops)
ops1 = sdpsettings('solver','bmibnb','bmibnb.maxiter',1000);
ops1 = sdpsettings(ops1,'bmibnb.uppersolver','fmincon');
ops2 = sdpsettings('solver','moment','moment.order',3)
for n = 1:10
    Q = magic(n);
    x = sdpvar(n,1);
    sol = optimize([-1 <= x <= 1],x'*Q*x,ops1);
    comptimes(n,1) = sol.solvertime;
    sol = optimize([-1 <= x <= 1],x'*Q*x,ops2);
    comptimes(n,2) = sol.solvertime;
end
```

```
semilogy(1:10,comptimes)
ops2 = sdpsettings('solver','moment','moment.order',2);
sol = optimize([-1 <= x <= 1,x x.*x <= 1],x'*Q*x,ops2);
ops= sdpsettings('solver','kktqp');
sol = optimize([-1 <= x <= 1],x'*Q*x,ops);
```

III. Simulation Results

In this section, the results of the presented code are demonstrated. Figure 1, the results of the proposed semidefinite relaxation method is compared with that of the global solver. As it is seen, any increase in the variable *n* results in the increase in performance of the technique.

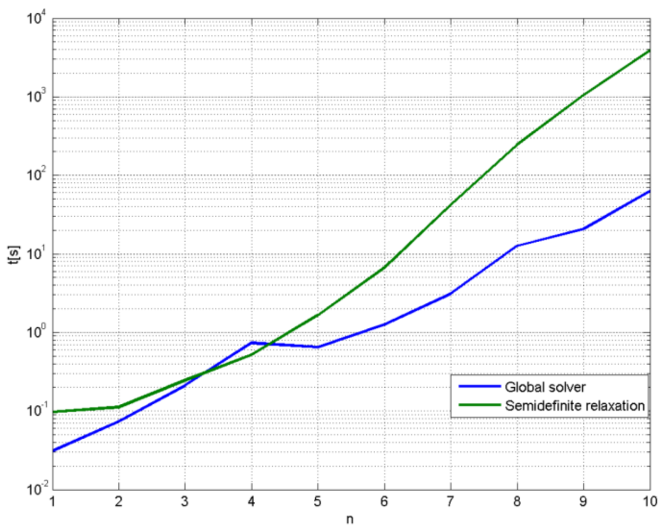

Figure 1. Semidefinite relaxation and Global solver methods comparision [34].

In figure 2, the performance of four techniques of Global solver, Semidefinite relaxation, Semidefinite relaxation with cut, and KKTQP is compared. According to that, the high performance of the Semidefinite relaxation technique is obviously seen.

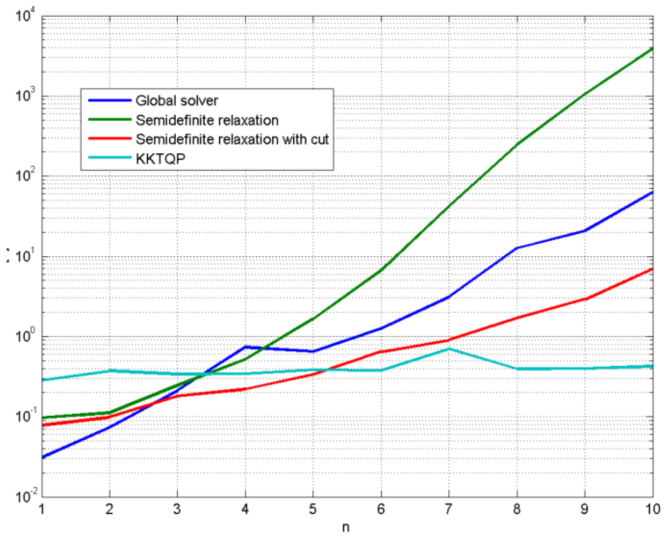

Figure 2. Global solver, Semidefinite relaxation, Semidefinite relaxation with cut, and KKTQP comparison.

IV. Conclusion

In this paper a new coding approach based on YALMIP software is presented. The method has shown its capabilities in comparison with conventional techniques such as KKTQP and Global solver and is practical for all nonconvex optimization problems.

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