# A New Nonconvex quadratic programming Technique: Practical and Fast Solver Method

Soltani, Ali and Tashakor, Behnam

Electrical and Computer Engineering Department, Payam Noor University Shiraz

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Ali Soltani, Bebnam Tashakor

Electrical and Computer Engineering Department, Payam Noor University Shiraz

***Abstract:*** There exist many problems that nonconvex which are hard to solve. To overcome the nonconvexity of the problems, this paper presents a novel YALMIP-based nonconvex quadratic programming model to overcome the nonconvex problem. The proposed method is accurate, and no need to convexify the problem. Finally, some results are presented to show the effectiveness and merit of the model.

## I. Introduction

In recent years, optimization problems have been attracted lots of attention [1-7] due to some significant advantages such as economic benefits, reliability enhancement, environmental benefits, etc. [8-14]. However, many of the optimization problems are non-convex and nonlinear, which are very hard to solve [15-19]. In the case that they can solve, the optimality of the solution is not assuring [20-22]. This is mainly because in many cases, the linearization approximation is needed that linearize the problem. However, even in the best case scenario, there exists an error between the linearized and nonlinear/nonconvex model [23-27].

There exist many solver and software to solve nonconvex problems. Among them, YALMIP is one of the fast and accurate Matlab based software that can overcome the non-convexity of the problems [27-30]. This software has been used in many sciences, e.g., engineering, geoscience, math, etc. [31-33]. To this end, this paper represents this technique as one of the best methods to overcome the nonconvex problems. The rest of this paper is organized as follows: Section II presents the semidefinite relaxation code of the YALMIP. Section III is the simulation result, followed by the conclusion in Section IV.

## II. Semidefinit Relaxation

The proposed code of the method can be defined as follow [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 Result

The results of the proposed code have been demonstrated as follows:

In figure 1, the proposed method, which is the semidefinite relaxation, has been compared with the global solver. The figure depicts the high performance of the method, by increasing $n$ as the variable.

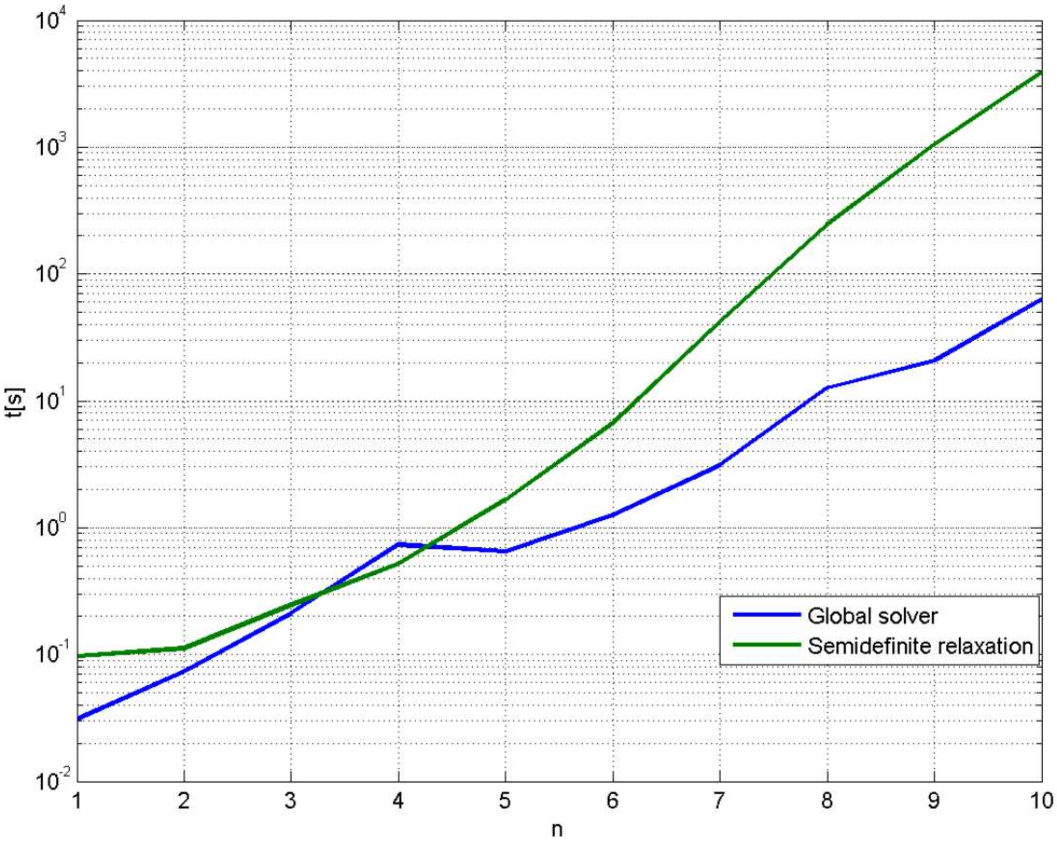


Figure 1. Comparing the Semidefinite relaxation and Global solver technique [34].

Also, figure 2 demonstrates the comparison of the Global solver, Semidefinite relaxation, Semidefinite relaxation with cut, and KKTQP as the most powerful techniques. The results prove the high performance of the Semidefinite relaxation technique.

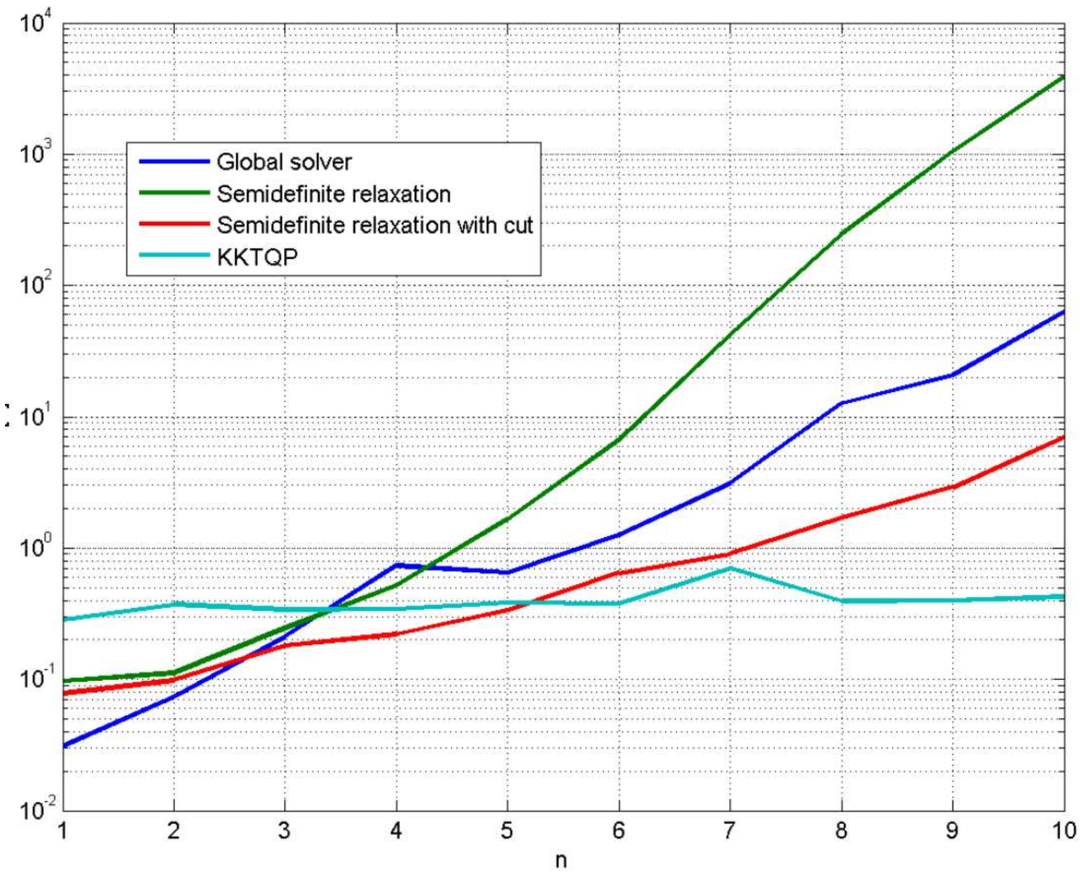


Figure 2. Comparison of Global solver, Semidefinite relaxation, Semidefinite relaxation with cut, and KKTQP.

## IV. Conclusion

This research presents a new coding approach based on YALMIP software. The proposed method has been merit in comparison with conventional techniques such as KKTQP and Global solver. The method is practical for all nonconvex optimization problems.

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