

The logo for Munich Personal RePEc Archive (MPRA) features the letters 'MPRA' in a large, blue, serif font. The letters have a subtle drop shadow effect, giving them a three-dimensional appearance as if they are floating slightly above the white background.

Munich Personal RePEc Archive

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

Ali Soltani and Behnam Tashakor

Electrical and Computer Engineering Department, Payam Noor  
University Shiraz

January 2019

Online at <https://mpra.ub.uni-muenchen.de/94335/>  
MPRA Paper No. 94335, posted 7 June 2019 15:40 UTC

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

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.ubbersolver','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.

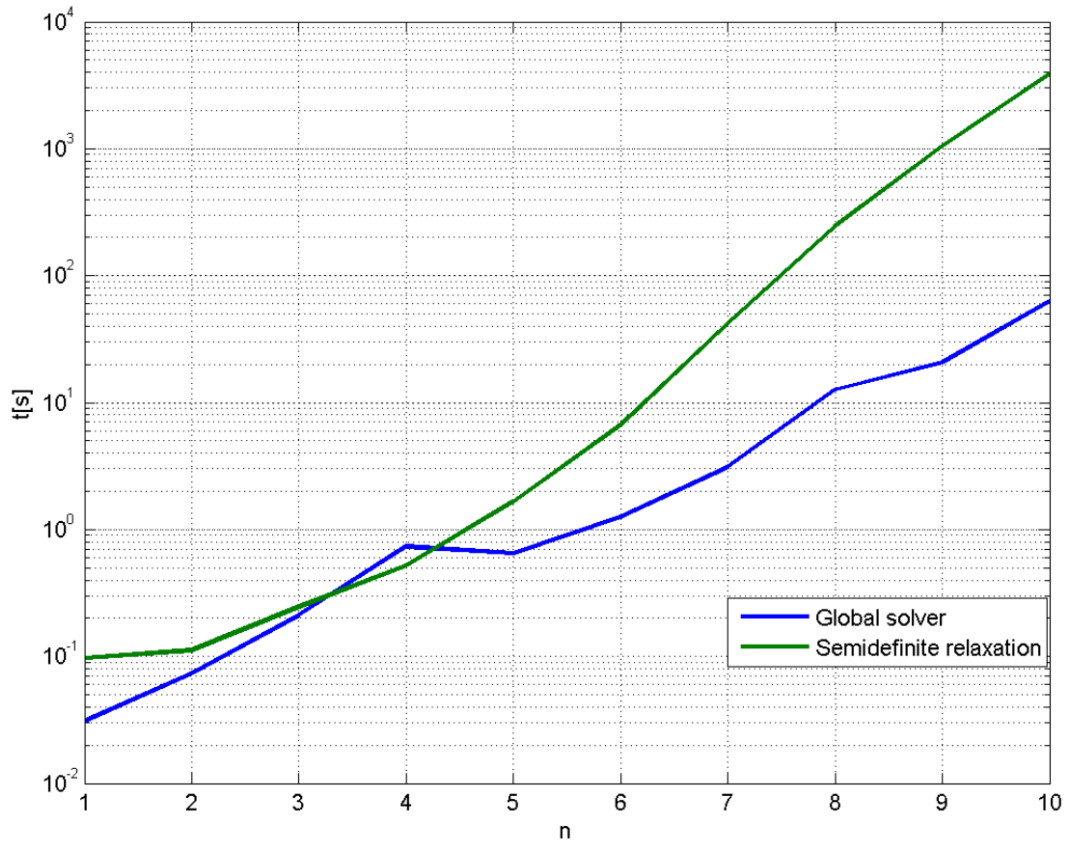


Figure 1. Comparing the Semidefinite relaxation and Global solver technique [34].

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.

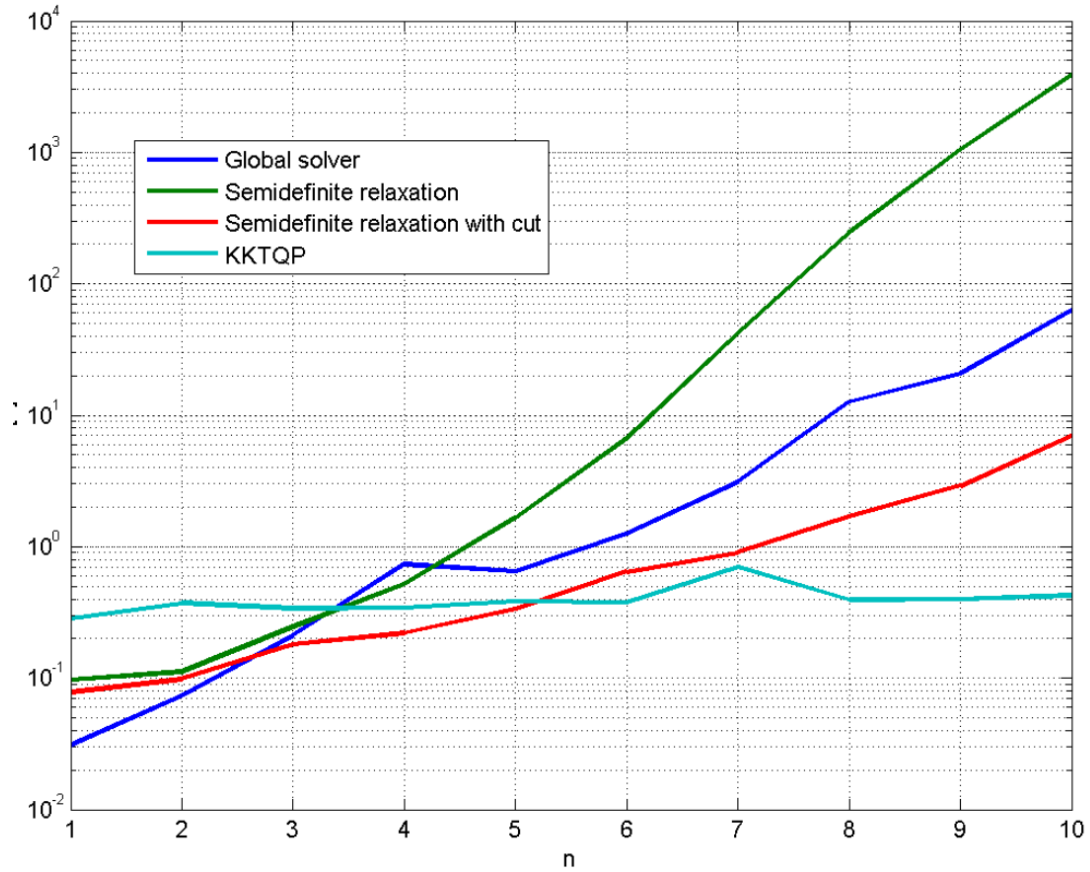


Figure 2. Comparison of Global solver, Semidefinite relaxation, Semidefinite relaxation with cut, and KKTQP.

#### 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.

## References

- [1] Zhang, Yin. "On Extending Some Primal--Dual Interior-Point Algorithms From Linear Programming to Semidefinite Programming." *SIAM Journal on Optimization* 8, no. 2 (1998): 365-386.
- [2] Fujie, Tetsuya, and Masakazu Kojima. "Semidefinite programming relaxation for nonconvex quadratic programs." *Journal of Global Optimization* 10, no. 4 (1997): 367-380.
- [3] Dabbaghjamanesh, M., A. Moeini, M. Ashkaboosi, P. Khazaei, and K. Mirzapalangi. "High Performance Control of Grid Connected Cascaded H-Bridge Active Rectifier Based on Type II-Fuzzy Logic Controller with Low Frequency Modulation Technique." *International Journal of Electrical & Computer Engineering (2088-8708)* 6, no. 2 (2016).
- [4] Ashkaboosi, Maryam, Seyed Mehdi Nourani, Peyman Khazaei, Morteza Dabbaghjamanesh, and Amirhossein Moeini. "An optimization technique based on profit of investment and market clearing in wind power systems." *American Journal of Electrical and Electronic Engineering* 4, no. 3 (2016): 85-91.
- [5] Khazaei, Peyman, Morteza Dabbaghjamanesh, Ali Kalantarzadeh, and Hasan Mousavi. "Applying the modified TLBO algorithm to solve the unit commitment problem." In *2016 World Automation Congress (WAC)*, pp. 1-6. IEEE, 2016.
- [6] Rakhshan, Mohsen, Navid Vafamand, Mokhtar Shasadeghi, Morteza Dabbaghjamanesh, and Amirhossein Moeini. "Design of networked polynomial control systems with random delays: sum of squares approach." *International Journal of Automation and Control* 10, no. 1 (2016): 73-86.
- [7] Vandenberghe, Lieven, and Stephen Boyd. "Semidefinite programming." *SIAM review* 38, no. 1 (1996): 49-95.
- [8] Haghshenas, S. Abbas, Sarmad Ghader, Daniel Yazgi, Edris Delkhosh, Nabiallah Rashedi Birgani, Azadeh Razavi Arab, Zohreh Hajisalami, Mohammad Hossein Nemati, Mohsen Soltanpour, and Morteza Jedari Attari. "Iranian Seas Waters Forecast-Part I: An Improved Model for The Persian Gulf." *Journal of Coastal Research* 85, no. sp1 (2018): 1216-1220.
- [9] Jedari Attari, Morteza, S. Abbas Haghshenas, Mohsen Soltanpour, Mohammad Reza Allahyar, Sarmad Ghader, Daniel Yazgi, Azadeh Razavi Arab, Zohreh Hajisalami, S. Jaafar Ahmadi, and Arash Bakhtiari. "Developing the Persian Gulf Wave Forecasting System." *Journal of Coastal and Marine Engineering* 1, no. 1 (2018): 13-18.
- [10] Zhao, Xin-Yuan, Defeng Sun, and Kim-Chuan Toh. "A Newton-CG augmented Lagrangian method for semidefinite programming." *SIAM Journal on Optimization* 20, no. 4 (2010): 1737-1765.
- [11] Dabbaghjamanesh, Morteza, Abdollah Kavousi-Fard, and Shahab Mehraeen. "Effective scheduling of reconfigurable microgrids with dynamic thermal line rating." *IEEE Transactions on Industrial Electronics* 66, no. 2 (2019): 1552-1564.
- [12] Ghaffari, Saeed, and Maryam Ashkaboosi. "Applying Hidden Markov Model Baby Cry Signal Recognition Based on Cybernetic Theory." *IJEIR* 5: 243-247.
- [13] Ashkaboosi, Maryam, Farnoosh Ashkaboosi, and Seyed Mehdi Nourani. "The Interaction of Cybernetics and Contemporary Economic Graphic Art as" Interactive Graphics"." (2016).
- [14] Ghaffari, Saeed, and M. Ashkaboosi. "Applying Hidden Markov M Recognition Based on C." (2016).
- [15] Dabbaghjamanesh, Morteza, Shahab Mehraeen, Abdollah Kavousifard, and Mosayeb Afshari Igder. "Effective scheduling operation of coordinated and uncoordinated wind-hydro and pumped-storage in generation units with modified JAYA algorithm." In *2017 IEEE Industry Applications Society Annual Meeting*, pp. 1-8. IEEE, 2017.
- [16] Dabbaghjamanesh, Morteza, Abdollah Kavousi-Fard, Shahab Mehraeen, Jie Zhang, and Zhao Yang Dong. "Sensitivity Analysis of Renewable Energy Integration on Stochastic Energy Management of Automated Reconfigurable Hybrid AC-DC Microgrid Considering DLR Security Constraint."
- [17] Parrilo, Pablo A. "Semidefinite programming relaxations for semialgebraic problems." *Mathematical programming* 96, no. 2 (2003): 293-320.
- [18] Dabbaghjamanesh, Morteza, Shahab Mehraeen, Abdollah Kavousi-Fard, and Farzad Ferdowsi. "A New Efficient Stochastic Energy Management Technique for Interconnected AC Microgrids." In *2018 IEEE Power & Energy Society General Meeting (PESGM)*, pp. 1-5. IEEE, 2018.
- [19] Razavi Arab, Azadeh, S. Abbas Haghshenas, and Farzin Samsami. "Sediment transport and morphodynamic changes in Ziarat Estuary and Mond River Delta, the Persian Gulf." In *EGU General Assembly Conference Abstracts*, vol. 16. 2014.
- [20] HAGHSHENAS, SEYED ABBAS, and ARAB AZADEH RAZAVI. "APPLICATION OF SEDIMENT CONSTITUENT ANALYSIS FOR CHARACTERIZING LONGSHORE SEDIMENT TRANSPORT, CASE STUDY OF RAMIN PORT-IRANIAN COASTLINE OF THE OMAN SEA." (2014).
- [21] Khazaei, P., S. M. Modares, M. Dabbaghjamanesh, M. Almousa, and A. Moeini. "A high efficiency DC/DC boost converter for photovoltaic applications." *International Journal of Soft Computing and Engineering (IJSCE)* 6, no. 2 (2016): 2231-2307.

- [22] d'Aspremont, Alexandre, Laurent E. Ghaoui, Michael I. Jordan, and Gert R. Lanckriet. "A direct formulation for sparse PCA using semidefinite programming." In *Advances in neural information processing systems*, pp. 41-48. 2005.
- [23] Arab, Azadeh Razavi, Afshin Danehkar, S. Abbas Haghshenas, and Gita B. Ebrahimi. "ASSESSMENT OF COASTAL DEVELOPMENT IMPACTS ON CORAL ECOSYSTEMS IN NAIBAND BAY, THE PERSIAN GULF." *Coastal Engineering Proceedings* 1, no. 33 (2012): 31.
- [24] So, Anthony Man-Cho, and Yinyu Ye. "Theory of semidefinite programming for sensor network localization." *Mathematical Programming* 109, no. 2-3 (2007): 367-384.
- [25] Haghshenas, S. Abbas, Azadeh Razavi Arab, Arash Bakhtiari, Morteza Jedari Attari, and Michael John Risk. "Decadal Evolution of Mond River Delta, the Persian Gulf." *Journal of Coastal Research* 75, no. sp1 (2016): 805-810.
- [26] Taherzadeh, Erfan, Morteza Dabbaghjamanesh, Mohsen Gitizadeh, and Akbar Rahideh. "A new efficient fuel optimization in blended charge depletion/charge sustenance control strategy for plug-in hybrid electric vehicles." *IEEE Transactions on Intelligent Vehicles* 3, no. 3 (2018): 374-383.
- [27] Tajalli, Seyede Zahra, Seyed Ali Mohammad Tajalli, Abdollah Kavousi-Fard, Taher Niknam, Morteza Dabbaghjamanesh, and Shahab Mehraeen. "A Secure Distributed Cloud-Fog Based Framework for Economic Operation of Microgrids." In *2019 IEEE Texas Power and Energy Conference (TPEC)*, pp. 1-6. IEEE, 2019.
- [28] Taherzadeh, Erfan, Shahram Javadi, and Morteza Dabbaghjamanesh. "New Optimal Power Management Strategy for Series Plug-In Hybrid Electric Vehicles." *International Journal of Automotive Technology* 19, no. 6 (2018): 1061-1069.
- [29] Dabbaghjamanesh, Morteza. "Stochastic Energy Management of Reconfigurable Power Grids in the Presence of Renewable Energy by Considering Practical Limitations." (2019).
- [30] Todd, Michael J., Kim-Chuan Toh, and Reha H. Tütüncü. "On the Nesterov--Todd Direction in Semidefinite Programming." *SIAM Journal on Optimization* 8, no. 3 (1998): 769-796.
- [31] Helmberg, Christoph. "Semidefinite programming for combinatorial optimization." (2000).
- [32] Azadeh, Razavi Arab, S. Abbas Haghshenas, Farzin Samsami, and Michael John Risk. "Traces of sediment origin in rheological behaviour of mud samples taken from the North-Western Persian Gulf." In *BOOK OF ABSTRACTS*. 2015.
- [33] Razavi Arab, Azadeh, S. Abbas Haghshenas, and Homayoun Zaker. "Deep water current velocity data in the Persian Gulf." In *EGU General Assembly Conference Abstracts*, vol. 17. 2015.
- [34] <https://valmip.github.io/example/nonconvexquadraticprogramming/>