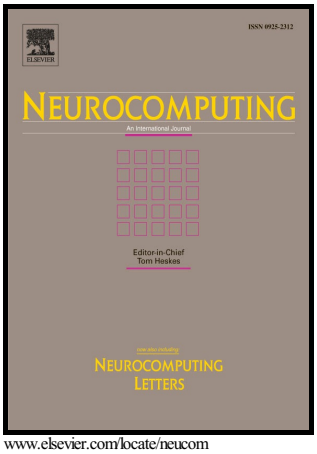


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# A Novel Neural Network for Solving Convex Quadratic Programming Problems Subject to Equality and Inequality Constraints

Xinjian Huang[a,b,*], Baotong Cui[a,b]

[a]*Key Laboratory of Advanced Process Control for Light Industry (Ministry of Education), Jiangnan University, Wuxi 214122, China*
[b]*School of IoT Engineering, Jiangnan University, Wuxi 214122, China*

**Abstract**

This paper proposes a neural network model for solving convex quadratic programming (CQP) problems, whose equilibrium points coincide with Karush-Kuhn-Tucker (KKT) points of the CQP problem. Using the equality transformation and Fischer-Burmeister (FB) function, we construct the neural network model and present the KKT condition for the CQP problem. Comparing with the existing neural networks for solving such problems, the proposed neural network model has less variables and neurons, which makes circuit realization easier. Moreover, the proposed neural network is asymptotically stable in the sense of Lyapunov such that it converges to an exact optimal solution of the CQP problem. The simulation results show that the proposed network is feasible and efficient.

*Keywords:* Neural Network, Convex Quadratic Programming, NCP Function, Stability.

## 1. Introduction

Quadratic programming problems have attracted much focus in recent years due to its wide applications in science and engineering including regression analysis[1], robot control[2], signal processing[3], image fusion[4], filter design and pattern recognition[5] et al. In many real-time applications, the optimization problems have a time-varying nature, which have to be solved in real time. However, most of conventional methods, like lagrange methods[5], interior-point methods[5], descent methods[5], penalty function methods[6] et al. might not be efficient enough for digital computers to solve the problem since the computing time required for a solution largely relies on the dimension and structure of the optimization problem, and the complexity of the algorithm used. One promising approach for handling these optimization problems is to employ artificial neural network methodology based on circuit implementation [7]. The neural network methodology arises in a wide variety of applications including pattern recognition[5], system identification and control[8], character recognition[9], image compression[10], model predictive control[11] and stock market prediction[12] et al. In the past two years, the neural network methodology have been extensively investigated for solving electromagnetic theory[13], combustion theory[14], nanotechnology[15], plasma physics[16], thin film flow problems[17], fluid mechanics problem[18] and magneto hydro dyamic[19], thus extended the application fields of neural networks.

The main advantage of neural network approach to optimization is that the nature of the dynamic solution procedure is inherently parallel and distributed. Therefore, the neural network approach can solve optimization problems in running time at the orders of magnitude much faster than the most popular optimization algorithms executed on general-purpose digital computers. In addition, neural network for solving optimization problem is hardware-implementable, that is to say, the neural network can be implemented by using integrated circuits.

The neural network for solving programming problems was first proposed by Tank and Hopfield [20]. Since then, different neural networks for solving different kinds of programming problems have been extensively studied and some achievements have also been obtained. In [21], based on gradient method and penalty function method, Kennedy and Chua propose a neural network for solving nonlinear programming problems. To avoid penalty parameters, Rodriguez-Vazquez et al.[22] propose a switched-capacitor neural network for solving a class of optimization problems. Applying the Lagrange multiplier theory, Wu and Tam [23] propose a Lagrange network for solving quadratic programming problems and Effati and Baymani [24] propose a Lagrange network for solving convex nonlinear programming problems. Huang [25] proposes a novel method to deal with inequality constraints in Lagrangian neural networks by redefining Lagrange multipliers as quadratic function. The method can solve some nonlinear programming and quadratic programming problems. In recent years, more neural networks to deal with linear programming, bilinear programming, nonlinear bilevel programming, quadratic programming and convex programming are presented. For instance, using a NCP-function, Effati and Nazemi [26] propose a recurrent neural networks for solving the linear and quadratic programming problems, which is proved to be stable in the sense of Lyapunov and globally convergent to an exact optimal solution of the programming problem. Sohrab Effati et al. [27] present a projection neural network for solving bilinear programming problems. In this paper, the bilinear programming problems and the

*Corresponding author
*Email address:* (Xinjian Huang)