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A Deformation-Adaptive First-Order Optimization Framework Using Jackson q-Gradients

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Abstract

We introduce Variable Jackson q-Gradient Descent (VJqGD), a first-order optimization method [1], inspired by recent advances in accelerated first-order methods for non-convex optimization . The proposed approach replaces the classical gradient with a Jackson q-gradient and progressively anneals the deformation parameter according to

$$q_k = 1 + (q_0 - 1)e^{-k/\tau}.$$

This mechanism enables a smooth transition from an exploratory non-local optimization regime toward classical gradient descent behavior as $q_k \to 1$, consistent with prior observations regarding the exploratory capabilities of q-gradient-based methods [2]. We further establish theoretical guarantees showing that, under standard smoothness assumptions and for $q > 1$ sufficiently close to 1, the Jackson q-gradient defines a valid descent direction on bounded sets, in line with modern analyses of first-order optimization methods [3].

The proposed method is evaluated on a diverse benchmark suite including Ackley, Rastrigin, Levy, Rosenbrock, Michalewicz, SumSquares, and EggHolder functions. Comparisons with Gradient Descent, Adam , RMSprop , and Adagrad are conducted using statistical tests and Dolan-Moré performance profiles. Experimental results demonstrate that VJqGD achieves competitive convergence and improved robustness on multimodal and ill-conditioned optimization landscapes, while also revealing limitations on highly deceptive functions such as Michalewicz.

Keywords: Gradient descent, q-calculus, q-derivative, Armijo rule, adaptive optimization.

References:

[1] O. F. Razzouki, A. Charroud, Z. El Allali, A. Chetouani and N. Aslimani, A survey of advanced gradient methods in machine learning. In Proc. 7th International Conference on Advanced Communication Technologies and Networking (CommNet), Rabat, Morocco, 2024, pp. 1–7.

[2] Y. Yang and B. Yang, An efficient non-negative least mean squares algorithm based on q-gradient for system identification. Digital Signal Processing 148 (2024), 104438, 9 pp.

[3] T. Rotaru, Exact Performance Analysis of Fundamental First-Order Optimization Methods. Ph.D. Dissertation, UCLouvain, 2026.