ΑΔΣ

Advances in Decision Sciences

Michael McAleer (Editor-in-Chief)

Chia-Lin Chang (Senior Co-Editor-in-Chief)

Alan Wing-Keung Wong (Senior Co-Editor-in-Chief and Managing Editor)

Aviral Kumar Tiwari (Co-Editor-in-Chief)

Montgomery Van Wart (Associate Editor-in-Chief)

Vincent Shin-Hung Pan (Managing Editor)

ASIA UNIVERSITY

SCIENTIFIC & BUSINESS World

Newton-Raphson Method: Approach and Applications

Sal Ly

Faculty of Mathematics and Statistics, Ton Duc Thang University,
Ho Chi Minh City, Vietnam
Email: lysal@tdtu.edu.vn

Kim-Hung Pho

Fractional Calculus, Optimization and Algebra Research Group, Faculty of Mathematics
and Statistics, Ton Duc Thang University, Ho Chi Minh City, Vietnam
Email: phokimhung@tdtu.edu.vn

Shin-Hung Pan

Department of Information Management
Chaoyang University of Technology, Taiwan
Email: vincentpan@cyut.edu.tw

Wing-Keung Wong

Department of Finance, Fintech Center, and Big Data Research Center,
Asia University, Taiwan, and
Department of Medical Research, China Medical University Hospital, Taiwan, and
Department of Economics and Finance, the Hang Seng University of Hong Kong,
Hong Kong
Corresponding author Email: **wong@asia.edu.tw**

Abstract

Purpose: The Newton-Raphson method (NRM) is a significant problem in statistics, Computational Mathematics, Applied Mathematics, and many other scientific fields, such as Engineering, Economics, and Decision Sciences, because its applications are extremely rich and diverse. This method can help scholars and practitioners solve some specific problems.

Design/methodology/approach: This method is widely used in Science because of its outstanding features. To contribute to the literature on this issue, this study details specific applications of the NRM.

Findings: We presented the most detailed Newton-Raphson method (NRM). We discuss its applications in practical problems, Statistics, Applied Mathematics, and other Sciences.

Originality/value: This study provides detailed and meaningful applications of the NRM for the first time.

Practical implications: This study aims to detail specific applications of the NRM. Four scenarios of applying the NRM to practical problems, Statistics, Applied Mathematics, and other Sciences are discussed in detail.

References

Agarwal, A., Hazan, E., Kale, S., & Schapire, R. E. (2006). Algorithms for portfolio manage- ment based on the newton method. *In Proceedings of the 23rd international conference on Machine learning*, 9-16.

Bakouch, H. S., Jazi, M. A., & Nadarajah, S. (2014). A new discrete distribution. *Statistics*, 48(1), 200-240.

Bhattacharya, P., & Bhattacharjee, R. (2010). A study on Weibull distribution for estimating the parameters. *Journal of Applied Quantitative Methods*, 5(2), 234-241.

Blum, W., & Niss, M. (1991). Applied mathematical problem solving, modelling, applica- tions, and links to other subjects—State, trends and issues in mathematics instruction. *Educational Studies in Mathematics*, 22(1), 37-68.

Bobkov, S. G. (1997). Some extremal properties of the Bernoulli distribution. *Theory of Probability and its Applications*, 41(4), 748-755.

Chen, X. (2000). Newton-type methods for stochastic programming. *Mathematical and Computer Modelling*, 31(10), 89-98.

Cohen, A. C. (1965). Maximum likelihood estimation in the Weibull distribution based on complete and on censored samples. *Technometrics*, 7(4), 579-588.

Coleman, T. F., Li, Y., & Verma, A. (2003). A Newton method for American option pricing. *Cornell University*.

Consul P. C., & Shoukri M. M. (1984). Maximum likelihood estimation for the generalized Poisson distribution. *Communications in Statistics-Theory and Methods*, 13(12), 1533- 1547.

Cox, D. R. (1958). The regression analysis of binary sequences. *Journal of the Royal Statistical Society Series B: Statistical Methodology*, 20(2), 215-232.

Doikov, N., & Nesterov, Y. (2024). Gradient regularization of Newton method with Bregman distances. Mathematical programming, 204(1), 1-25.

Ezquerro, J. A., Gonzalez, D., & Hernandez, M. A. (2012). Majorizing sequences for New- ton's method from initial value problems. *Journal of Computational and Applied Mathematics*, 236(9), 2246-2258.

Gatilov, S. Y. (2014). Using low-rank approximation of the Jacobian matrix in the New- ton–Raphson method to solve certain singular equations. *Journal of Computational and Applied Mathematics*, 272, 8-24.

Gaudreau, P., Hayami, K., Aoki, Y., Safouhi, H., & Konagaya, A. (2015). Improvements to the cluster Newton method for underdetermined inverse problems. *Journal of Computa- tional and Applied mathematics*, 283, 122-141.

Gobet, E., & Grangereau, M. (2022). Newton method for stochastic control problems. *SIAM Journal on Control and Optimization*, 60(5), 2996-3025.

Gutkin, E. (2012). Capillary floating and the billiard ball problem. *Journal of Mathematical Fluid Mechanics*, 14, 363-382.

Hassan, B. A., & Moghrabi, I. A. (2023). A modified secant equation quasi-Newton method for unconstrained optimization. *Journal of Applied Mathematics and Computing*, 69(1), 451-464.

Lambert, D. (1992). Zero-inflated Poisson regression, with an application to defects in manufacturing. *Technometrics*, 34(1), 1-14.

Long, J. H., Hu, X. Y., & Zhang, L. (2008). Improved Newton's method with exact line searches to solve quadratic matrix equation. *Journal of Computational and Applied Math- ematics*, 222(2), 645-654.

Lukusa, T. M., Lee, S. M., & Li, C. S. (2016). Semiparametric estimation of a zero-inflated Poisson regression model with missing covariates. *Metrika*, 79, 457-483.

Morini, B., Porcelli, M., & Chan, R. H. (2010). A reduced Newton method for con- strained linear least-squares problems. *Journal of Computational and Applied Mathe- matics*, 233(9), 2200-2212.

Mudzimbabwe, W., & Vazquez, C. (2016). Newton methods for option pricing with liquidity switching. *Numerical Methods for Scientific Computations and Advanced Applications (NMSCAA'16)*, 58-62.

Myung, I. J. (2003). Tutorial on maximum likelihood estimation. *Journal of Mathematical Psychology*, 47(1), 90-100.

Na, S., Dereziński, M., & Mahoney, M. W. (2023). Hessian averaging in stochastic Newton methods achieves superlinear convergence. *Mathematical Programming*, *201*(1), 473-520.

Pho, K. H. (2022). Improvements of the Newton–Raphson method. *Journal of Computa- tional and Applied Mathematics*, 408, 114106.

Pho, K. H., Ho, T. D. C., Tran, T. K., & Wong, W. K. (2019). Moment Generating Function, Expectation and Variance of Ubiquitous Distributions with Applications in Decision Sciences: A Review. *Advances in Decision Sciences*, 23(2), 65-150.

Pho, K. H., & McAleer, M. (2021). Specification and estimation of a logistic function, with applications in the sciences and social sciences. *Advances in Decision Sciences*, (2), 1-30.

Sereeter, B., Vuik, C., & Witteveen, C. (2019). On a comparison of Newton–Raphson solvers for power flow problems. *Journal of Computational and Applied Mathematics*, 360, 157- 169.

Singh, S. (1963). A note on inflated Poisson distribution. *Journal of the Indian Statistical Association*, 1, 140-144.

Smietanski, M. J. (2007). A generalized Jacobian based Newton method for semismooth block-triangular system of equations. *Journal of Computational and Applied Mathemat- ics*, 205(1), 305-313.

Smietanski, M. J. (2011). Some quadrature-based versions of the generalized Newton method for solving nonsmooth equations. *Journal of Computational and Applied Mathematics*, 235(17), 5131-5139.

Truong, B. C., Nguyen, V. B., Truong, H. V., & Ho, T. D. C. (2019a). Comparison of optim, nleqslv and MaxLik to estimate parameters in some of regression models. *Journal of Advanced Engineering and Computation*, 3(4), 532-550.

Truong, B. C., Van Thuan, N., Hau, N. H., & McAleer, M. (2019b). Applications of the Newton-Raphson method in decision sciences and education. *Advances in Decision Sci- ences*, (4), 1-28.

Tuan, B. A., Pho, K. H., Pan, S. H., & Wong, W. K. (2022). Applications in Sciences in the prevention of COVID-19. *Advances in Decision Sciences*, 26(4), 1-16.

Vasudeva Rao, A., Dattatreya Rao, A. V., & Narasimham, V. L. (1994). Asymptotically optimal grouping for maximum likelihood estimation of Weibull parameters. *Communi- cations in Statistics-Simulation and Computation*, 23(4), 1077-1096.

Wagh, Y. S., & Kamalja, K. K. (2018). Zero-inflated models and estimation in zero-inflated

Poisson distribution. *Communications in Statistics-Simulation and Computation*, 47(8), 2248-2265.

Xu, L. (2015). Application of the Newton iteration algorithm to the parameter estimation for dynamical systems. *Journal of Computational and Applied Mathematics*, 288, 33-43.

Zhou, H. Y., Wu, S. L., & Li, C. X. (2021). Newton-based matrix splitting method for generalized absolute value equation. *Journal of Computational and Applied Mathematics*, 394, 113578.

Zhou, W., & Zhang, L. (2020). A modified Broyden-like quasi-Newton method for nonlinear equations. *Journal of Computational and Applied Mathematics*, 372, 112744.