Parameter Estimation of Lorenz Attractor: A Combined Deep Neural Network and K-Means Clustering Approach

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Abstract This research is mainly aimed at introducing a deep learning approach to solve chaotic system parameter estimates like the Lorenz system. The reason for the study is that because of its dynamic instability, the parameter of the chaotic system cannot be easily estimated. Moreover, due to the complexity of chaotic systems based on existing approaches, some parameters may be difficult to determine in advance. Therefore, it is crucial to assess the parameter of chaotic systems. To solve the issue of parameter estimation for a chaotic system, deep learning is utilized. After that, it has been suggested to improve the efficiencies in the Deep Neural Network (DNN) model by combining the DNN with an unsupervised machine learning algorithm, the K-Means clustering algorithm. This study constructs the flow of DNN based method with the K-Means algorithm. DNN techniques is suitable in solving nonlinear and complex problem. The most popular method to solve parameter estimation problem is using optimization algorithm that easily trap to local minima and poor in exploitation to find the good solutions. Due to the flow, 80% of training and 20% test sets for each class are divided between the Lorenz datasets. Accuracy by using 80:20 ratio of training and test data gives result 98% of accurate training data, and 73% of test data are predicted with the proposed algorithm while 91 and 40% of the DNN models are predicted in training and test data.

Keywords Machine learning · Chaos system · Deep neural network · K-means clustering · Parameter estimation

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10. Wei J, Yu Y (2017) An effective hybrid cuckoo search algorithm for unknown parameters and time delays estimation of chaotic systems. IEEE Access 6:6560–6571
11. Gu W, Yu Y, Hu W (2017) Artificial bee colony algorithmbased parameter estimation of fractional-order chaotic system with time delay. IEEE/CAA J Autom Sin 4:107–113
12. Chen S, Yan R (2016) Parameter estimation for chaotic systems based on improved boundary chicken swarm optimization. Infrared Technol Appl Robot Sens Adv Control 10157:101571K
13. Xu S, Wang Y, Liu X (2018) Parameter estimation for chaotic systems via a hybrid flower pollination algorithm. Neural Comput Appl 30:2607–2623
14. Zhang H, Li B, Zhang J, Qin Y, Feng X, Liu B (2016) Parameter estimation of nonlinear chaotic system by improved TLBO strategy. Soft Comput 20:4965–4980
15. Xu C, Yang R (2017) Parameter estimation for chaotic systems using improved bird swarm algorithm. Mod Phys Lett B 31:1–15
16. Mariño IP, Míguez J (2006) An approximate gradient-descent method for joint parameter estimation and synchronization of coupled chaotic systems. Phys Lett Sect A Gen At Solid State Phys 351:262–267
17. Xishuang D, Lijun Q, Lei H (2017) Short-term load forecasting in smart grid: a combined CNN and K-means clustering approach. In: 2017 IEEE international conference on big data and smart computing (BigComp), pp 119–125
18. Barrio R, Dena A, Tucker W (2015) A database of rigorous and high-precision periodic orbits of the Lorenz model. Comput Phys Commun 194:76–83