FAST COMPUTATIONAL APPROACH TO THE LEVENBERG-MARQUARDT ALGORITHM FOR TRAINING FEEDFORWARD NEURAL NETWORKS

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Abstract

This paper presents a parallel approach to the Levenberg-Marquardt algorithm (LM). The use of the Levenberg-Marquardt algorithm to train neural networks is associated with significant computational complexity, and thus computation time. As a result, when the neural network has a big number of weights, the algorithm becomes practically ineffective. This article presents a new parallel approach to the computations in Levenberg-Marquardt neural network learning algorithm. The proposed solution is based on vector instructions to effectively reduce the high computational time of this algorithm. The new approach was tested on several examples involving the problems of classification and function approximation, and next it was compared with a classical computational method. The article presents in detail the idea of parallel neural network computations and shows the obtained acceleration for different problems.

Keywords: feed-forward neural network, neural network learning algorithm, Levenberg-Marquardt algorithm, QR decomposition, Givens rotation.

1 Introduction

Currently, artificial intelligence (AI) is widely used both in science research and in industry. Among the issues of artificial intelligence, neural networks (NN) deserve special attention. Continually many researchers pub-

lish a lot of scientific papers about artificial intelligence [1, 2], especially about neural networks e.g. [3, 4, 5, 6, 7, 8, 9, 10, 11]. There are more and more advanced AI solutions and methods that are willingly used in industry and various products. Important areas of neural networks applications are health care and

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Training Feedforward Networks With The Marquardt Algorithm:

Machine Learning-Based Modelling in Atomic Layer Deposition Processes Oluwatobi Adeleke,Sina Karimzadeh,Tien-Chien Jen,2023-12-15 While thin film technology has benefited greatly from artificial intelligence AI and machine learning ML techniques there is still much to be learned from a full scale exploration of these technologies in atomic layer deposition ALD This book provides in depth information regarding the application of ML based modeling techniques in thin film technology as a standalone approach and integrated with the classical simulation and modeling methods It is the first of its kind to present detailed information regarding approaches in ML based modeling optimization and prediction of the behaviors and characteristics of ALD for improved process quality control and discovery of new materials As such this book fills significant knowledge gaps in the existing resources as it provides extensive information on ML and its applications in film thin technology Offers an in depth overview of the fundamentals of thin film technology state of the art computational simulation approaches in ALD ML techniques algorithms applications and challenges Establishes the need for and significance of ML applications in ALD while introducing integration approaches for ML techniques with computation simulation approaches Explores the application of key techniques in ML such as predictive analysis classification techniques feature engineering image processing capability and microstructural analysis of deep learning algorithms and generative model benefits in ALD Helps readers gain a holistic understanding of the exciting applications of ML based solutions to ALD problems and apply them to real world issues Aimed at materials scientists and engineers this book fills significant knowledge gaps in existing resources as it provides extensive information on ML and its applications in film thin technology It also opens space for future intensive research and intriguing opportunities for ML enhanced ALD processes which scale from academic to industrial applications *Valorization of Biomass to Value-Added Commodities* Michael O. Daramola,Augustine O. Ayeni,2020-04-21 This book presents the most up to date technologies for the transformation of biomass into valuable fuels chemicals materials and products It provides comprehensive coverage of the characterization and fractionation of various types of biomass and details the many challenges that are currently encountered during this process Divided into two sections this book discusses timely topics such as the characterization of biomass feedstock pretreatment and fractionation of biomass and describes the process for conversion of biomass to value added commodities The authors bring biomass transformational strategies that are yet to be explored to the forefront making this innovative book useful for graduate students and researchers in academia government and industry **Intelligent Systems** Bogdan M. Wilamowski,J. David Irwin,2018-10-03 The Industrial Electronics Handbook Second Edition combines traditional and newer more specialized knowledge that will help industrial electronics engineers develop practical solutions for the design and implementation of high power applications Embracing the broad technological scope of the field this collection explores fundamental areas including analog and digital circuits electronics electromagnetic machines signal processing and

industrial control and communications systems It also facilitates the use of intelligent systems such as neural networks fuzzy systems and evolutionary methods in terms of a hierarchical structure that makes factory control and supervision more efficient by addressing the needs of all production components Enhancing its value this fully updated collection presents research and global trends as published in the IEEE Transactions on Industrial Electronics Journal one of the largest and most respected publications in the field As intelligent systems continue to replace and sometimes outperform human intelligence in decision making processes they have made substantial contributions to the solution of very complex problems As a result the field of computational intelligence has branched out in several directions For instance artificial neural networks can learn how to classify patterns such as images or sequences of events and effectively model complex nonlinear systems Simple and easy to implement fuzzy systems can be applied to successful modeling and system control Illustrating how these and other tools help engineers model nonlinear system behavior determine and evaluate system parameters and ensure overall system control Intelligent Systems Addresses various aspects of neural networks and fuzzy systems Focuses on system optimization covering new techniques such as evolutionary methods swarm and ant colony optimizations Discusses several applications that deal with methods of computational intelligence Other volumes in the set Fundamentals of Industrial Electronics Power Electronics and Motor Drives Control and Mechatronics Industrial Communication Systems

Neural Information Processing Derong Liu,Shengli Xie,Yuanqing Li,Dongbin Zhao,El-Sayed M. El-Alfy,2017-11-07 The six volume set LNCS 10634 LNCS 10635 LNCS 10636 LNCS 10637 LNCS 10638 and LNCS 10639 constitues the proceedings of the 24rd International Conference on Neural Information Processing ICONIP 2017 held in Guangzhou China in November 2017 The 563 full papers presented were carefully reviewed and selected from 856 submissions The 6 volumes are organized in topical sections on Machine Learning Reinforcement Learning Big Data Analysis Deep Learning Brain Computer Interface Computational Finance Computer Vision Neurodynamics Sensory Perception and Decision Making Computational Intelligence Neural Data Analysis Biomedical Engineering Emotion and Bayesian Networks Data Mining Time Series Analysis Social Networks Bioinformatics Information Security and Social Cognition Robotics and Control Pattern Recognition Neuromorphic Hardware and Speech Processing   **TIME SERIES FORECASTING USING NEURAL NETWORKS. EXAMPLES WITH MATLAB** Cesar Perez Lopez, MATLAB has the tool Deep Leraning Toolbox that provides algorithms functions and apps to create train visualize and simulate neural networks You can perform classification regression clustering dimensionality reduction timeseries forecasting and dynamic system modeling and control Dynamic neural networks are good at timeseries prediction You can use the Neural Net Time Series app to solve different kinds of time series problems It is generally best to start with the GUI and then to use the GUI to automatically generate command line scripts Before using either method the first step is to define the problem by selecting a data set Each GUI has access to many sample data sets that you can use to experiment with the toolbox If you have a specific problem that you want to solve

you can load your own data into the workspace With MATLAB is possibe to solve three different kinds of time series problems In the first type of time series problem you would like to predict future values of a time series y t from past values of that time series and past values of a second time series x t This form of prediction is called nonlinear autoregressive network with exogenous external input or NARX In the second type of time series problem there is only one series involved The future values of a time series y t are predicted only from past values of that series This form of prediction is called nonlinear autoregressive or NAR The third time series problem is similar to the first type in that two series are involved an input series predictors x t and an output series responses y t Here you want to predict values of y t from previous values of x t but without knowledge of previous values of y t This book develops methods for time series forecasting using neural networks across MATLAB **Neural Information Processing** Chu Kiong Loo,Yap Keem Siah,Kok Wai Wong,Andrew Teoh Beng Jin,Kaizhu Huang,2014-10-20 The three volume set LNCS 8834 LNCS 8835 and LNCS 8836 constitutes the proceedings of the 20th International Conference on Neural Information Processing ICONIP 2014 held in Kuching Malaysia in November 2014 The 231 full papers presented were carefully reviewed and selected from 375 submissions The selected papers cover major topics of theoretical research empirical study and applications of neural information processing research The 3 volumes represent topical sections containing articles on cognitive science neural networks and learning systems theory and design applications kernel and statistical methods evolutionary computation and hybrid intelligent systems signal and image processing and special sessions intelligent systems for supporting decision making processes theories and applications cognitive robotics and learning systems for social network and web mining **Applied Mechanics and Mechatronics II** František Trebuňa,2015-11-30 Special topic volume with invited peer reviewed papers only **BIG DATA ANALYTICS: CLUSTER ANALYSIS AND PATTERN RECOGNITION. EXAMPLES WITH MATLAB** CESAR PEREZ LOPEZ,2020-05-31 Big Data Analytics examines large amounts of data to uncover hidden patterns correlations and other insights MATLAB has the tool Neural Network Toolbox Deep Learning Toolbox from version 18 that provides algorithms functions and apps to create train visualize and simulate neural networks You can perform classification regression clustering dimensionality reduction time series forecasting and dynamic system modeling and control The toolbox includes convolutional neural network and autoencoder deep learning algorithms for image classification and feature learning tasks To speed up training of large data sets you can distribute computations and data across multicore processors GPUs and computer clusters using Big Data tools Parallel Computing Toolbox Unsupervised learning algorithms including self organizing maps and competitive layers Apps for data fitting pattern recognition and clustering Preprocessing postprocessing and network visualization for improving training efficiency and assessing network performance his book develops cluster analysis and pattern recognition *Nondestructive Evaluation of Aging Aircraft, Airports, and Aerospace Hardware* ,2000 *Smart Engineering System Design* Cihan H. Dagli,1999 Proceedings of the Artificial Neural Networks in Engineering Conference November 5 8 2000 St Louis Missouri

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