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Tutorial Title

Artificial Neural Networks for Power Electronics – A Hands-On Approach

Instructor Team

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Abstract

Power electronics systems consist of power electronic switching devices, linear circuit elements, digital circuits, microprocessors, electromagnetic devices, DSPs, filters, controllers, sensors, etc.,and the advanced development of these systems and their applications include many areas of knowledge such as solid-state physics, circuit theory, power systems, systems and control theory,simulation and computing, signal processing, electronics, electric machines, electromagnetics, among others. The problems faced during such development may include (Optimum) Converterdesign, Control, Modulation, Energy management, System Integration, Parameter estimation, System Identification, Diagnostics, Prognostics, Fault tolerance operation, etc. Many of these problems are ill-posed and contain uncertainties, and using standard first-principle mathematicalmodeling can be impossible, time-consuming, and/or lack precision. Therefore, for them, lately,data-driven modeling is becoming more and more needed.

Among many data-driven techniques, Artificial Neural Network (ANN) is one of the best options. However, many power electronics researchers that start applying this technique to solve their power electronics problems can make mistakes in at least one of the steps of the ANN development process and therefore struggle to successfully implement them.

The fundamental phases of the ANN developments process are: i) formulating the problem, ii) identifying the type of problem, iii) selecting the best architecture to solve the problem, iv) generating/collecting the data; v) choosing the ANN development platform, vi) designing the ANN; vii) defining the stop criteria; viii) choosing the training algorithm, ix) splitting the data into training, testing, and validation datasets; x) training, testing, and validating the ANN; xi) implementing the ANN (software or hardware); xii) deploying the implemented ANN. Therefore, training in the whole process, with a good understanding of each phase, is crucial to increase the successful use of such a powerful technique.

This tutorial will provide a background in the ANN principles and a practical and detailed description of all phases for using this technique. Then, a discussion of the most common power type of problems in power electronics will be provided. In the sequence, three power electronics problems will be described and the use of ANN to solve them will be addressed in a hands-on approach, i.e., each attendee will design, train, test, validate, software implement, and deploy them during the tutorial, acquiring the knowledge to develop research in ANN applications aimed at power electronics.

Instructor Biography

Joao O. P. Pinto, received his B.S and MS in Electrical Engineering from the Universidade EstadualPaulista, and the Universidade Federal de Uberlândia, in Brazil, in 1990 and 1993 respectively, and his Ph.D. from The University of Tennessee, in Knoxville, in 2001. He was a Faculty Member at the Federal University of Mato Grosso do Sul, Brazil, from 1994 to 2021, where founded and direct BATLAB, Artificial Intelligence/Machine Learning (AI/ML) Applications, Power Electronics and Drives, and Energy Systems. He is a Faculty Member of the Federal University of Rio de Janeiro, Brazil, on leave of absence since 2021. Currently, he is a Senior Researcher at Oak RidgeNational Laboratory, Oak Ridge, U.S. Dr. Pinto was an early pioneer in AI/ML applications to power electronics and motor drives. Hestarted to work in this area in 1997 as part of the research for his PhD at the University of Tennessee, Knoxville. More than half of his more than 200 papers published in journals and conference proceedings are in the AI/ML application. In the past two decades, Dr. Pinto has given numerous seminars and tutorials at conferences and universities around the world,expanding the fundamentals, new applications, and trends in this area.

Burak Ozpineci, received the B.S. degree in electrical engineering from Orta Dogu Technical University, Ankara, Turkey, in 1994, and the M.S. and Ph.D. degrees in electrical engineering fromThe University of Tennessee, Knoxville, TN, USA, in 1998 and 2002, respectively. In 2001, he joined the Post-Master's Program with Power Electronics and Electric Machinery Group, Oak Ridge National Laboratory (ORNL), Knoxville, TN, USA. He became a Full Time Research and Development Staff Member in 2002, the Group Leader of the Power and Energy Systems Group in 2008, and Power Electronics and Electric Machinery Group in 2011. Presently, he is a CorporateFellow at ORNL serving as the Section Head for the Vehicle and Mobility System Research Section.He is also a Joint Faculty with the Bredesen Center, The University of Tennessee. Dr. Ozpineci is a Fellow of IEEE.

Marcio L. M. Kimpara, received his B.S and MS in Electrical Engineering from the Federal University of Mato Grosso do Sul (UFMS), Campo Grande, Brazil, in 2009 and 2012, respectively,and his Ph.D. from the Federal University of Itajuba (UNIFEI), Brazil, in 2018. Since 2014 he is a Faculty Member at the Federal University of Mato Grosso do Sul, Brazil, on leave of absence for post-doctorate research at Oak Ridge National Laboratory, Oak Ridge, U.S. Dr. Kimpara has experience in motor drives, power electronics, digital systems, and optimization algorithms, and has worked with different AI/ML techniques over the years. He has experience in giving lectures on AI techniques and modeling using Matlab.