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Georgiev, Svetlin

Neural network methods for dynamic equations on time scales. (English) Zbl 08115297

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Volumes in the SpringerBriefs series want to summarize a broader topic on some 50 to 125 pages. In this case it is like a summary of an introductory course on artificial neural nets (ANN) as they are applied to model dynamical systems. However, at least in this case, although it approaches the subject in a very elementary way, as if starting from scratch, it is not a replacement of the lecture notes, since it is assumed that the reader is familiar with some concepts and notation from dynamical systems. For example, notation is used without definition, like $y^{\Delta^n}(v)$, $\frac{\partial E}{\Delta w}$, $e_{\ominus\lambda}(x,x_0)$ or $\sinh_f(x,x_0)$ where the Δ refers to the time scale (continuous or discrete), but that is not standard notation for a general undergraduate math course. These different time scales, are in the title of the book, and they are an essential element in the present treatment of the subject. A minimum of theory and methods is included, just enough to understand the expanded numerical examples followed by some exercises with their eventual answers included.

This being said, the text starts with an elementary introduction to ANN with one hidden layer, the possible activation functions and how the ANN learns to adapt its weight parameters. Chapter 2 introduces multiple hidden layers as they are applied to initial value or boundary value problems of first, second, and nth order. To minimize the error measuring the difference between a result predicted by the ANN and the solution satisfying the dynamics, it is explained how to compute its gradient with respect to the parameters.

Chapter 3 treats regression-based neural nets (RBNN) where the objective is to match a set $\{(t_i,y_i)\}_{i\in I}$ of input-output pairs using a polynomial trial function.

The two remaining chapters discuss particular choices of the polynomial basis used to represent the approximant. Chapter 4 discusses Chebyshev neural nets (ChNN). It starts by defining the four types of Chebyshev polynomials and deriving their properties. This is then applied in the context of regression. Chapter 5 defines Legendre neural nets (LeNN) which is like the previous one, but using Legendre polynomials instead of Chebyshev polynomials.

Reviewer: Adhemar Bultheel (Leuven)

MSC:

65-02 Research exposition (monographs, survey articles) pertaining to numerical analysis
34N05 Dynamic equations on time scales or measure chains
68T07 Artificial neural networks and deep learning
34B15 Nonlinear boundary value problems for ordinary differential equations

Keywords:

neural network; dynamical system; time scale; regression neural network

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