



# Approximation Properties of Max-Min Neural Network Operators of Durrmeyer Type

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## Abstract

In recent years, nonlinear neural network operators have gained significant importance in approximation theory, particularly following the introduction of maximum-minimum neural network operators in [1]. Subsequent research has led to the development of their Kantorovich-type generalizations to handle broader classes of functions [2]. While linear Durrmeyer-type operators have also been investigated [3], this study introduces a novel Durrmeyer-type generalization of univariate max-min neural network operators, with theoretical foundations further established in [4].

We systematically investigate the approximation behavior of these operators within  $L^p$ -spaces ( $1 \leq p < \infty$ ). Theoretical contributions include the establishment of pointwise, uniform, and  $L^p$ -convergence, alongside quantitative estimates for the rates of approximation using the modulus of continuity and  $K$ -functionals. Numerical experiments demonstrate that our integral-based Durrmeyer-type max-min operators yield superior signal denoising performance against both Gaussian and impulsive noise when compared to the operators in [1, 2].

**Keywords:** Nonlinear operators, max-min operators, durrmeyer-type operators, neural network operators, signal filtering, approximation theory.

## References:

- [1] İ. Aslan, Approximation by max-min neural network operators. *Numer. Funct. Anal. Optim.* 46 (2025), no. 4-5, 374–393.
- [2] İ. Aslan, S. De Marchi and W. Erb,  $L^p$ -convergence of Kantorovich-type max-min neural network operators. arXiv preprint, arXiv:2407.03329 (2024).
- [3] L. Coroianu, D. Costarelli, M. Natale and A. Pantiş, The approximation capabilities of Durrmeyer-type neural network operators. *J. Appl. Math. Comput.* 70 (2024), no. 5, 4581–4599.
- [4] B. Şahin and İ. Aslan, On the  $L^p$ -convergence and denoising performance of Durrmeyer-type max-min neural network operators. arXiv preprint, arXiv:2601.22174 (2026).