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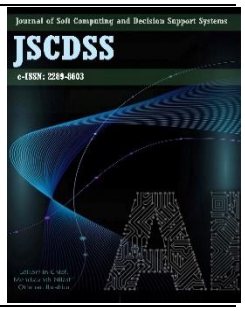

Synergistic Hybrid AI Framework for Optimized Iris Recognition: BWT-RBFNN-ICA (BRICA) Model

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Abstract

This study details the Berkeley Wavelet Transform with Imperialist Competitive Radial Basis Network (BRICA) model, an advanced hybrid artificial intelligence framework designed for human iris recognition to achieve high accuracy and computational efficiency. The proposed architecture combines the Berkeley Wavelet Transform (BWT) for spatial-frequency feature extraction with a Radial Basis Function Neural Network (RBFNN) optimized by the Imperialist Competitive Algorithm (ICA) for pattern classification. Evaluated on benchmark iris datasets, this system achieves exceptional performance, reaching over 99.99% accuracy on CASIA-Iris V3 and 99.96% on the UCI dataset, alongside a low Equal Error Rate (EER $< 0.02\%$) and minimal computational overhead. The findings demonstrate that combining BWT multi-resolution extraction with ICA-driven neural network optimization provides a fast, highly accurate, and robust solution for real-world biometric applications.

Keywords: Iris Recognition, BRICA Model, Berkeley Wavelet Transform, Radial Basis Function Neural Network, Imperialist Competitive Algorithm

1. Introduction

Biometric identification has revolutionized modern identity verification by leveraging unique physiological and behavioral traits to authenticate individuals [1]. These traits encompass a wide spectrum of modalities, including iris patterns [2–4] facial geometry, fingerprints, retinal scans, palm prints, and voice signatures [1,5]. Among these options, the human iris recognition system (HIRS) is widely recognized as the gold standard in secure biometric identification due to the exceptional distinctiveness, spatial stability, and longevity of the human iris [6–8], [6,9–13]. The complex epigenetic patterns formed by pigment spots, furrows, and ridges remain virtually static throughout an individual's lifetime and exhibit high degrees of freedom, rendering even the left and right irises of the same person entirely unique [7,14].

Despite notable advancements in biometric image processing and machine learning, existing iris recognition architectures continue to face critical trade-offs regarding computational complexity, generalization capabilities, and environmental noise sensitivity [15]. Traditional approaches frequently rely on single-feature extraction techniques or isolated classification algorithms, which limits their adaptability across heterogeneous imaging datasets [16]. Furthermore, modern deep learning topologies-such as convolutional neural networks (CNNs)-demand extensive processing power and memory allocation, making them sub-optimal for edge devices or real-time biometric applications [17–26].

To address these core limitations, this paper introduces the BRICA (BWT-RBFNN-ICA) framework-a synergistic hybrid artificial intelligence architecture designed for rapid, highly accurate iris texture identification. The primary contributions of this work are summarized as follows:

i. Efficient multi-resolution feature extraction: The model integrates the Berkeley wavelet transform (BWT) to capture multi-scale spatial-frequency iris characteristics across four distinct orientations $(0°, 45°, 90°, 135°)$, drastically cutting extraction runtime to 2.66 seconds.