Abstract

This research presents a comprehensive and integrative approach to the understanding, diagnosis, and management of breast cancer by combining mathematical modeling with advanced artificial intelligence (AI) techniques. The study places a particular emphasis on the BreakHis histopathological image dataset to enhance diagnostic precision and treatment evaluation.

The initial phase of the research involves the development of a mathematical model that encapsulates the dynamic behavior of breast cancer progression, specifically evaluating the efficacy of combined chemotherapy and monoclonal antibody treatments. Employing the Z-control technique and rigorous stability analysis, the model demonstrates a notable reduction in cancer cell proliferation, corroborated by extensive numerical simulations and graphical interpretations. A comparative analysis between two control strategiesZ-control and optimal controlis conducted on the same dynamical system. The findings from numerical simulations offer deeper insights into their relative effectiveness in modulating cancer dynamics.

A pivotal focus of this work lies in the early detection and diagnosis of breast cancer through artificial neural networks (ANNs), trained on the BreakHis dataset. A novel weight-updating algorithm is introduced for training these networks, outperforming conventional methods such as Gradient Descent and RMSprop in terms of classification accuracy and convergence performance.

Furthermore, the study proposes a Modified Firefly Algorithm for optimizing neural network training in breast cancer detection. This algorithm is benchmarked against other nature-inspired optimization techniques, demonstrating superior results. To further refine the models efficiency, advanced feature extraction methodssuch as Gabor filters and Local Binary Patternsare utilized.

In addition, the integration of Convolutional Neural Networks (CNNs) for feature extraction, in conjunction with the proposed weight-updating algorithm, leads to an exceptional classification accuracy of 100% on the BreakHis dataset. This result underscores the robustness and effectiveness of the combined methodology in the early and precise detection of malignant breast tissue.

In summary, this research offers a comprehensive approach to breast cancer dynamics by integrating mathematical modeling and advanced AI, contributing significantly to medical diagnostics.