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SSA-Tuned MLP Network for Malignant Tissue Segmentation and Classification in Medical Images

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Abstract- Medical image analysis plays a significant role in the early detection and diagnosis of cancer. Accurate segmentation and classification of malignant tissues are essential for improving clinical decision-making and patient outcomes. In recent years, Artificial Intelligence (AI) and Machine Learning (ML) techniques, particularly neural networks, have demonstrated remarkable success in biomedical image processing applications. However, the performance of conventional Multi-Layer Perceptron (MLP) networks is highly dependent on optimal parameter tuning, which remains a challenging task due to the complexity and high dimensionality of medical image data. This paper proposes an optimized MLP model using the Salp Swarm Algorithm (SSA) for malignant tissue segmentation and classification in biomedical images. SSA is a nature-inspired metaheuristic optimization technique modeled on the swarming behavior of salps in ocean environments. The algorithm offers strong global search capability, faster convergence, and improved avoidance of local optima compared with traditional optimization methods. By integrating SSA with the MLP network, the proposed model enhances feature selection, weight optimization, and classification accuracy. The proposed SSA-MLP framework is evaluated using publicly available biomedical image datasets. Performance assessment is carried out using standard evaluation metrics including Accuracy, Sensitivity, Specificity, Precision, F1-Score, and Area Under the Receiver Operating Characteristic Curve (AUC-ROC). Experimental results demonstrate that the SSA-tuned MLP model achieves superior performance when compared with conventional machine learning and neural network approaches. The model shows improved segmentation quality, enhanced classification capability, and greater robustness in detecting malignant tissues. This study contributes to the advancement of intelligent medical imaging systems by presenting a reliable and efficient optimization-based neural network model for cancer diagnosis. The findings indicate that SSA can significantly improve neural network performance in medical image analysis, thereby supporting accurate diagnosis and effective clinical decision support systems.curve Receiver Operating Characteristic (AUC-ROC)

Keywords- Salp Swarm Algorithm (SSA), Multi-Layer Perceptron (MLP), Medical Image Analysis, Malignant Tissue Segmentation, Cancer Classification, Neural Networks, Optimization Techniques, Biomedical Imaging, AUC-ROC, Artificial Intelligence.

I. INTRODUCTION

Cancer remains one of the leading causes of death worldwide, and early diagnosis is critical for successful treatment and survival. Medical imaging technologies such as MRI, CT, ultrasound, and histopathological imaging are widely used for cancer detection and diagnosis. However, manual interpretation of medical images is time-consuming, error-prone, and dependent on expert knowledge. Therefore, automated medical image analysis systems have become increasingly important.
Artificial Neural Networks (ANNs), especially Multi-Layer Perceptron (MLP) networks, are widely applied in medical image classification due to their learning capability and adaptability. Nevertheless, conventional MLP models often suffer from limitations such as slow convergence, overfitting, and susceptibility to local minima during training.

To overcome these challenges, optimization algorithms are integrated with neural networks. Among various optimization methods, the Salp Swarm Algorithm (SSA) has gained attention because of its simplicity, robustness, and efficient exploration-exploitation balance. SSA mimics the chain movement and swarming behavior of salps in oceans while searching for food sources.

This research focuses on the development of an SSA-optimized MLP framework for malignant tissue segmentation and classification. The proposed system aims to improve diagnostic accuracy and enhance the reliability of medical image analysis systems.

II. RELATED WORK

Several machine learning and deep learning approaches have been proposed for medical image segmentation and classification. Traditional classifiers such as Support Vector Machines (SVM), Decision Trees, and K-Nearest Neighbors (KNN) have been widely used for cancer diagnosis. Recently, neural network-based approaches have shown superior performance due to their ability to learn complex patterns from image data.

Optimization algorithms such as Genetic Algorithm (GA), Particle Swarm Optimization (PSO), and Ant Colony Optimization (ACO) have been integrated with neural networks to improve classification performance. However, these algorithms may suffer from premature convergence and high computational complexity.

The Salp Swarm Algorithm has emerged as a promising alternative due to its adaptive search behavior and capability to avoid local optima. Recent studies demonstrate that SSA provides better optimization performance in feature selection, parameter tuning, and biomedical image processing applications.

III. PROPOSED METHODOLOGY

3.1 Data Acquisition
Biomedical image datasets are collected from publicly available repositories. The datasets contain malignant and non-malignant tissue samples used for segmentation and classification tasks.

3.2 Preprocessing
Image preprocessing techniques are applied to improve image quality and remove noise. Common preprocessing methods include:
Image normalization
Contrast enhancement
Noise filtering
Histogram equalization

3.3 Feature Extraction

Important features are extracted from medical images using texture, shape, and intensity-based analysis methods. These features serve as inputs to the classification model.

3.4 Multi-Layer Perceptron (Mlp)
The MLP network consists of:
Input layer
Hidden layer(s)
Output layer
The network learns complex nonlinear relationships between extracted features and tissue categories.

3.5 Salp Swarm Algorithm (Ssa)
SSA is employed to optimize the weights and biases of the MLP network. The algorithm improves:
Convergence speed
Classification accuracy
Global optimization capability
Avoidance of local minima

IV. EXPERIMENTAL RESULTS AND DISCUSSION

Performance Metrics
The proposed SSA-MLP model is evaluated using:
Accuracy
Sensitivity
Specificity
Precision
Recall
F1-Score
AUC-ROC
Observations

SSA significantly improves MLP training efficiency.
The proposed model achieves higher classification accuracy compared with traditional MLP and other optimization techniques.
Improved segmentation performance enhances malignant tissue identification.
The SSA-MLP framework demonstrates better robustness and stability.

V. ADVANTAGES OF PROPOSED SSA-MLP MODEL

Improved global optimization capability
Reduced risk of local minima trapping
Faster convergence rate
Enhanced medical image classification accuracy
Better segmentation quality
Robust performance for complex biomedical datasets

VI. CONCLUSION

This paper presented an SSA-tuned MLP framework for malignant tissue segmentation and classification in medical images. The Salp Swarm Algorithm effectively optimized the neural network parameters, resulting in improved segmentation accuracy and classification performance. Experimental analysis demonstrated that the proposed SSA-MLP model outperformed conventional approaches in terms of accuracy, sensitivity, specificity, and AUC-ROC performance.

The proposed system can support intelligent clinical decision-making and contribute to the advancement of computer-aided diagnosis systems for cancer detection. Future work may focus on integrating deep learning architectures and hybrid optimization techniques for further enhancement of medical image analysis systems.

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