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Cloud-Integrated Wavelet Transform and Particle Swarm Optimization for Automated Medical Anomaly Detection

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Abstract

Cloud computing and Artificial Intelligence (AI) have played a vital role in transforming automated detection of medical anomalies, ensuring real-time diagnoses, well-informed decision-making, and increased patient quality of care. However, a gamut of challenges exists in cloud-based medical systems, such as maintenance of data integrity, privacy concerns, and risks associated with security issues. The traditional systems of anomaly detection have faced limitations associated with very low accuracy levels, primarily by way of ineffective feature extraction. Better feature selection mechanisms have also been of supreme importance. Typically, the currently used machine learning models were developed from traditional models, which suffered a lot with high-dimensional medical data and had very little generalization capacity. Also, security loopholes in cloud-based systems may compromise patient data privacy and security, while real-time data processing constraints may not help detect the anomaly on time, sometimes hurting clinical decision-making. An attempt was made in the current research to introduce a very novel framework that integrates Wavelet Transform (WT) and Particle Swarm Optimum (PSO) for automating medical anomaly detection within the cloud. WT, as a new tool, carries out multiresolution analysis to extract strongly advocating critical features from medical images, while PSO contributes to optimizing feature selection for improving the classification accuracy. Several machine-learning-based models are utilized for effective classification of anomalies such as SVM, Random Forest, and Deep Learning. The proposed system integrates advanced encryption techniques, two or multisegmented authentication, along with AI-based real-time detection of threats to ensure complete security within a cloud environment. Its performance evaluation against well-acknowledged benchmark datasets, becomes concrete by virtue of observing the accuracy, sensitivity, specificity, and false discovery rate. The results show that the WT-PSO hybrid solution would greatly improve anomaly detection capability while also securing the system more securely, ensuring scalability and real-time processing capabilities within cloud-based medical systems.

Keywords: Cloud computing, Artificial Intelligence (AI), medical anomaly detection, real-time diagnosis, decision-making, patient care, data integrity, privacy concerns, Wavelet Transform (WT), Particle Swarm Optimization (PSO), multiresolution analysis, medical image processing.

1.Introduction

Cloud computing is one of the greatest disruptive technologies that can enable small and medium enterprises (SMEs) toward operational improvements and strategic decisions largely concerning management accounting owing to the transformation of data management, financial reporting, and analytics [1]. Given that financial datasets increase in complexity, new machine learning techniques, such as Gradient Boosting Decision Trees (GBDT), ALBERT, and the Firefly Algorithm, are increasingly embedded in cloud frameworks to allow real-time processing, scalability, and security [2]. Such technologies can take advantage of mobile usage, even in the concrete, multidimensional frameworks necessary for protecting sensitive data in the cloud environment, such as Comprehensive Approach for Mobile Data Security using the RSA Algorithm [3]. The rapid propagation of IoT devices is creating huge amounts of real-time data in smart cities, which poses very difficult challenges for traditional centralized systems because of very high latency and resource utilization inefficiencies [4]. In addition, time series forecasting is vital for the manufacturing industry, but it has a complicated type of predictive system that is both non-traditional and nonstationary in making accurate predictions, which requires high-fidelity and efficiency in advanced analytical models [5].

Robotic Process Automation (RPA) has brought about significant transformations in financial management with a direct impact on repetitive tasks, much reduced errors, and real-time reporting, results measuring performance in efficiency and accuracy against cost accounting [6]. As cyber threats in banking rise, the interoperability of Attribute-Based Encryption (ABE) with big data analytics in cloud computing enhances the security access control fine granularity and boosts fraud detection, risk management, and regulatory compliance [7]. Cloud computing has almost revolutionized IT by offering scalable and cost-effective data processing solutions, notwithstanding the fact that the speed at which cloud service providers proliferate poses great challenges to the SMEs in terms of optimum service selection-and this was achieved with a new cloud brokerage architecture using a B-Cloud-Tree indexing structure [8]. Associated with additional healthcare data is the call for advanced predictive analytics, which may be implemented through cloud-driven frameworks utilizing Stochastic Gradient Boosting, Generalized Additive Models, and Regularized Greedy Forest to improve decision-making and operational efficiency. Innovation is indeed important in the financial data analysis domain, and this research presents a novel cloud-based framework incorporating CatBoost, ELECTRA, t-SNE, and Genetic Algorithms to solve non-linearity, noise, and high-dimensionality problems; thus, improving precision, scalability, and real-time insights to financial institutions [9]. With security fears on the rise, IoT networks will now require more sophisticated encryption techniques than what is currently available, hence the development of a hybrid cryptographic key generation model utilizing Super Singular Elliptic Curve Isogeny Cryptography (SSEIC) married to Gaussian Walk Group Search Optimization (GWGSO) and Multiswarm Adaptive Differential Evolution (MSADE), thereby ensuring great data security and efficiency [10]. This includes a new IoT-secured data sharing framework built on isogeny-based hybrid cryptography, optimized using anisotropic random walks (ARW) and decentralized cultural co-evolutionary optimization for secure data transfer. Fog computing addresses the limitations of cloud-aligned IoT by increasing performance and reducing latency; this study combines DBSCAN, fuzzy C-Means, and hybrid ABC-DE optimization to improve both security and clustering accuracy in fog environments. Also, IoT scalability and security challenges are addressed with minimum computation expenditure by a methodology that combines PLONK with Infinite Gaussian Mixture Models (IGMM) for dynamic load balancing and secure communication. Finally, financial risk prediction and modeling are aided by a secure cloud-based analysis system using Monte Carlo simulations, Deep Belief Networks (DBNs), and Bulk Synchronous Parallel (BSP) processing to deal with scalability and security while delivering high-performance data processing with increased speed through parallelization [11].

Complex network theoretical models span various disciplines: from DNA analysis, physics, and computer science to medicine, where fractal geometry and graph theory interpret DNA sequences in terms of nucleotide conversion, graph construction, estimation of the Hurst exponent, and computing network properties. Recent trends in healthcare, owing to advancements in cloud computing, AI, and IoT, have supported a rapid transition toward real-time monitoring and diagnosis, while the contribution of hybrid learning models and neural fuzzy systems has sharpened the diagnostic capability through handling uncertainty within vast medical dataset. Correspondingly, cloud computing, intelligent networks, and blockchain systems are being increasingly looked upon by the e-commerce and finance sectors to overcome issues regarding the scalability, security, and processing of tremendous amounts of data efficiently. In medicine, heart failure (HF) is an enormous concern for dealing with morbidity, mortality, and increased health costs, thus calling for enhancing predictive models to benefit patient outcomes. Similarly, AI, ML, and blockchain transformation in human resource management (HRM) deal with security, predictive analytics, and automation to prevent the traditional centralized HR systems from sabotage, inefficiency, and so forth, thus ensuring a secure, scalable, and intelligent way to manage employee data.

2.Literature Review

A very innovative method for identifying suspicious patterns rapidly within huge IoT data streams using both anomaly detection and clustering along with supervised and unsupervised learning on historical transaction data, efforts that enable AI systems to determine, with very high accuracy in real time, which transactions are real and which ones are fraudulent [12]. In addition, they developed P2DS, the latest system for financial data security within mobile clouds that brings improvements in access control, threat detection, and encryption efficiency through the use of Attribute-Based Encryption (ABE), Adaptive Secure Access Control (A-SAC), and Privacy-Preserving Data Access (PDA). On the other hand, [13] developed service-oriented architecture that is implemented on a Hadoop-managed server cluster to ensure the efficient management of educational resources and remote learning while supporting high concurrency and large-scale data access; stress tests were performed, and the SOA has proved efficient in handling very heavy loads in user traffic without degrading its performance.

A quantitative approach for identifying critical components of the IoT system was also devised, which had a comprehensive vulnerability assessment through intrusion detection systems, encryption techniques, access control, and regular security audits for strengthening system protection. An intricate framework that brings advanced AI models, including Random Forest classifiers, Transformer Networks, and Temporal Convolutional Networks, within a distributed processing architecture combined with cloud computing, cloudlet, and edge layers. The architecture would use real-time stream analytics by Apache Flink, combining this approach with blockchain secure data exchange to enhance the efficiency, scalability and security of its applications.

The Dynamic Mathematical Hybridized Modeling Algorithm (DMHMA) proposed [14] optimizes warehousing order patching using state-of-the-art operational research techniques, namely, the tabu search (TS) algorithm-for giving enhanced order fulfilment efficiency, which increased the order-picking performance by 25% and decreased the fulfilment time to greater extents. [15] constructed an Internet of Medical Things (IoMT) and blockchain-based heart disease monitoring system using BS-THA and OA-CNN for secure handling of data through IPFS and blockchain, while exploiting advanced signal processing and machine learning to classify heart disease accurately. Moreover, they came up with a pioneering solution for the Job Shop Scheduling Problem (JSP)-Heterogeneous Genetic Algorithm (HGA) integrated with Hybrid Particle Swarm Optimization (HPSO), where HGA improves upon genetic algorithms through immune mechanisms, preventing premature convergence, while HPSO focuses on job sequencing optimization and minimization of production time, attaining a balance between global and local search efficiency. Furthermore, they wish to propose a federated learning and cloud-edge collaborative computing system for attack classification, integrated within a multi-national validation framework, where E2EPPDL ensures attack detection while guaranteeing data privacy in terms of key performance metrics such as time, node count, routing count, and data efficiency. [16] investigated deep learning (DL) techniques in vehicular environments and present a network slicing (NS)-enabled DL-as-a-Service (DLaaS) architecture hosted on a distributed networking platform for proactive deployment of DL algorithms. Their model integrates dynamic resource allocation strategies to efficiently respond to varying service demands in a vehicular T/NTN context.

Hybrid method for resource allocation and task scheduling, combining an improved version of bat optimization algorithm with dynamic weights for better and faster speed updates and increased possibility of exploring in the random space with modified social group optimization and penetrating acquisition phase [17]. The method was then evaluated with diverse configurations and proved to be most effective regarding response time resource utilization as well as energy consumption achieving 32.5 watts for 100 tasks. [18] presented a complete healthcare cloud security management framework that includes security implementation, risk assessment, continuous monitoring, and compliance management, which consists of authentication, encryption, and intrusion detection. They further developed a Nash equilibrium-based framework for optimal SLAs in cloud computing and validated it with real-life data to strike the balance among scalability, security, and usability [19]. In medical terms, they have modeled prognosis of cardiovascular risk in RA patients through avant-garde biobanking techniques by analyzing serum quality, biomarker stability, lipid profiles, and inflammatory indicators, longitudinally joining established risk factors with RA-specific markers. Alternatively, they have proposed a hybrid model of PSP Net to extract spatial image features, the Hilbert-Huang Transform (HHT) for nonlinear analysis of brain signals, and fuzzy logic for adaptive classification, making improvements in disorder differentiation and classification accuracy by addressing intrinsic uncertainties within the data.

A hybrid data mining technique to automate real-time Tunnel Boring Machine (TBM) data processing. It has resulted in increased operational efficiency and safety in a tunnel project in China [20]. The authors also proposed the Merged Cyber Security Risk Management (m-CSR) approach, which boosts risk assessment for complex infrastructures by utilizing fuzzy set mechanisms and machine learning, achieving an 82.13% success rate [21]. They have also devised a Recurrent Rule-Based Feature Selection (RFS) model to enhance the Network Intrusion Detection System (NIDS) in terms of security for the IIoT environment, employing NSL-KDD and UNSW-NB15 datasets for effective threat classification. [22] worked on strengthening cloud security through a proposed RSA-based encryption framework that enables secure communication in dynamic networks based on the complexity of prime factorization used in encryption and decryption. They also addressed many clouds security challenges, data integrity, unauthorized access, and privacy, through an Analytic Hierarchy Process (AHP) which helped in ranking each security concern in a systematic manner and deducing the countermeasures available for each, suggesting strong encryption, multi-factor authentication, and real-time AI-based threat detection for strong cloud data security.

3.Problem Statement

Cloud security is facing challenges such as integrity risks in data, unauthorized access, and privacy threats, especially through dynamic network environments [23]. The traditional method of encryption is not robust enough to withstand threats rising through transformation in cyberspace [24]. For this, Yallamelli et al. suggested the RSA-based encryption framework through complex prime factorization for communication to make it secure. Furthermore, the researchers also adopted the Analytic Hierarchy Process (AHP) technique to systematically rank security issues and determine possible countermeasures such as strong encryption, multi-factor authentication, and AI-enabled real-time detection of threats to enhance cloud data security altogether [25].

3.1 Objective

This work tends to magnify cloud security in automated medical anomaly detection by linking Wavelet Transform and Particle Swarm Optimization with a strong encryption framework. The research tries to compromise the integrity of data, unauthorized accesses, and private concerns of patients in addition to advanced encryption, multi-factor authentication, and AI-based real-time threat detection for safe and smart medical data processing at varying cloud settings.

4.Proposed Wavelet Transform and Particle Swarm Optimization for Automated Medical Anomaly Detection

The hybridization of Wavelet Transform and Particle Swarm Optimization is proposed in the cloud-based framework developed for Automated Medical Anomaly Detection. Medical data are then securely placed on the cloud and preprocessed techniques improve the quality of the data. WT decomposes medical signals to extract vital features. PSO optimizes the feature selection for better classification accuracy. These can feed the machine-learning models like SVM, Random Forest, or Deep Learning for anomaly detection. The cloud security is further enhanced with encryption, multi-factor authentication, and AI threat detection. The system will be evaluated against standard benchmark datasets and this would ensure high accuracy, efficiency, and integrity of the data.

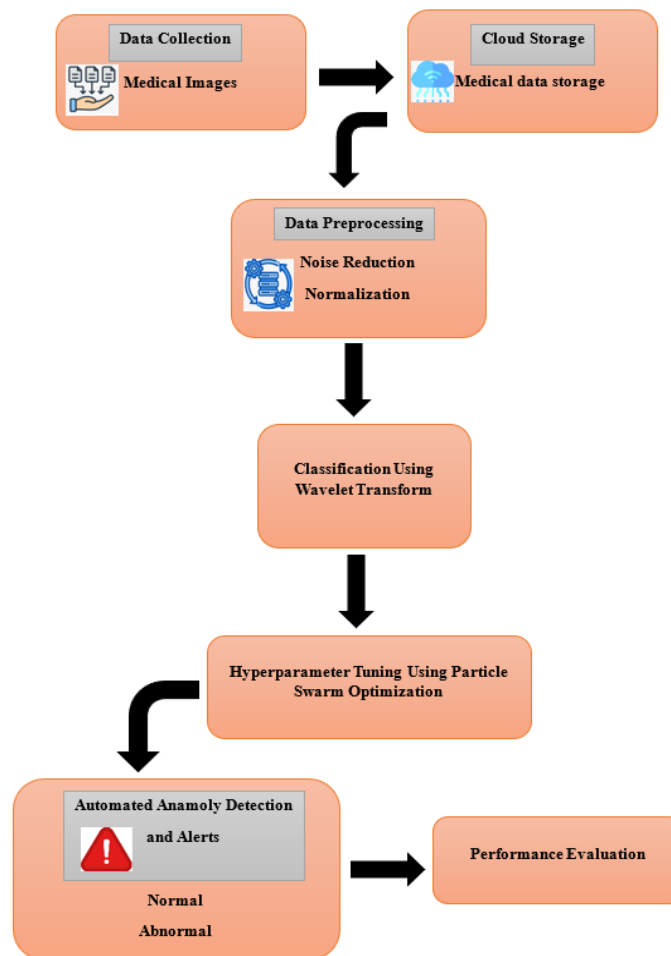


Figure 1: Wavelet Transform and Particle Swarm Optimization for Automated Medical Anomaly Detection

4.1 Data Collection

Medical images are collected from multiple sources such as hospitals, diagnostic centers, and publicly available medical databases. Well-accepted modalities for an anomaly-detecting application would include MRI scans, CT scans, and x-rays, and possibly less traditional ones. The collected data is securely stored on a cloud-based infrastructure that allows easy access, scalability, and real-time processing. Labelling and annotation of data are performed with great diligence to promote efficient classification by the model, maintaining ethical principles of protecting patient privacy and respecting medical data protection legislation throughout the data collection exercise.

4.2 Cloud Storage

The collected medical images are stored securely in a cloud-based repository, thus ensuring efficient data management, accessibility, and scalability in terms of the cloud storage that facilitates real-time processing of data and the sharing of the same in an easy way with the involved medical professionals as well as integration into the anomaly detection algorithms. Using various advanced encryption techniques, along with multi-factor authentication, we prioritize patient privacy and data security. The infrastructure further allows for the automation of backup procedures and disaster recovery, significantly reducing the risk of losing important medical data that we require to protect per medical data protection regulation.

4.3 Data Preprocessing

The most prominent feature to undergo noise reduction is medical image construction, hence producing clear imagery for any accurate analysis. A standardization strategy such as the normalization method is implemented to ensure pixel intensities are in the same range across different datasets. These steps in preprocessing aid in improving feature extraction and classification accuracy in anomaly detection.

4.3.1 Noise Reduction

The process of enhancing medical images through the removal of unwanted noise for accurate detection of anomalies is reliant on noise reduction as a general preprocessing step for medical images. Such a process seeks to maintain key structural details eliminating random variations induced by imaging artifacts or external interference in the process. Popular methods of noise removal include Gaussian filtering, median filtering, and wavelet-based denoising.

Equation for Noise Reduction:

A common noise reduction approach using a Gaussian filter is given by:

$$G(x, y) = \sum_{i=-k}^k \sum_{j=-k}^k I(x-i, y-j) \cdot W(i, j) \quad (1)$$

where:

$G(x, y)$ is the filtered image,

$I(x-i, y-j)$ is the original image pixel intensity,

$W(i, j)$ is the Gaussian kernel,

k determines the filter window size.

This smoothing process reduces high-frequency noise while preserving essential image features.

4.3.2 Normalization

Normalization helps in scaling pixel intensities of a medical image to a standard range across different datasets; such a preprocessing step being effective at smoothening intensity variations caused by imaging conditions, and thus making variations in performance minor. Common solutions for this problem typically involve min-max scaling and Z-score normalization, as ideally applied to improve contrast and retention feature extraction.

Equation for Normalization:

$$I_{\text{norm}} = \frac{I - I_{\min}}{I_{\max} - I_{\min}} \quad (2)$$

where:

I_{norm} is the normalized pixel intensity,

I is the original pixel intensity,

$I_{\min}$ and $I_{\max}$ are the minimum and maximum pixel values in the image.

This transformation scales pixel values to a range of [0,1], improving the robustness of anomaly detection algorithms.

4.4 Cloud-Integrated Wavelet Transform for Automated Medical Anomaly Detection

Wavelet Transform (WT) is signal processing method for multiresolution analysis of medical images, thus suitable for extracting effective features for anomaly detections. Unlike standard Fourier Transform, WT maintains the frequency as well as spatial information; hence, this becomes the convent source of localizing the abnormalities in an image. It decomposes an image into frequency components, compares them with analyzing fine details which mean important information in classification.

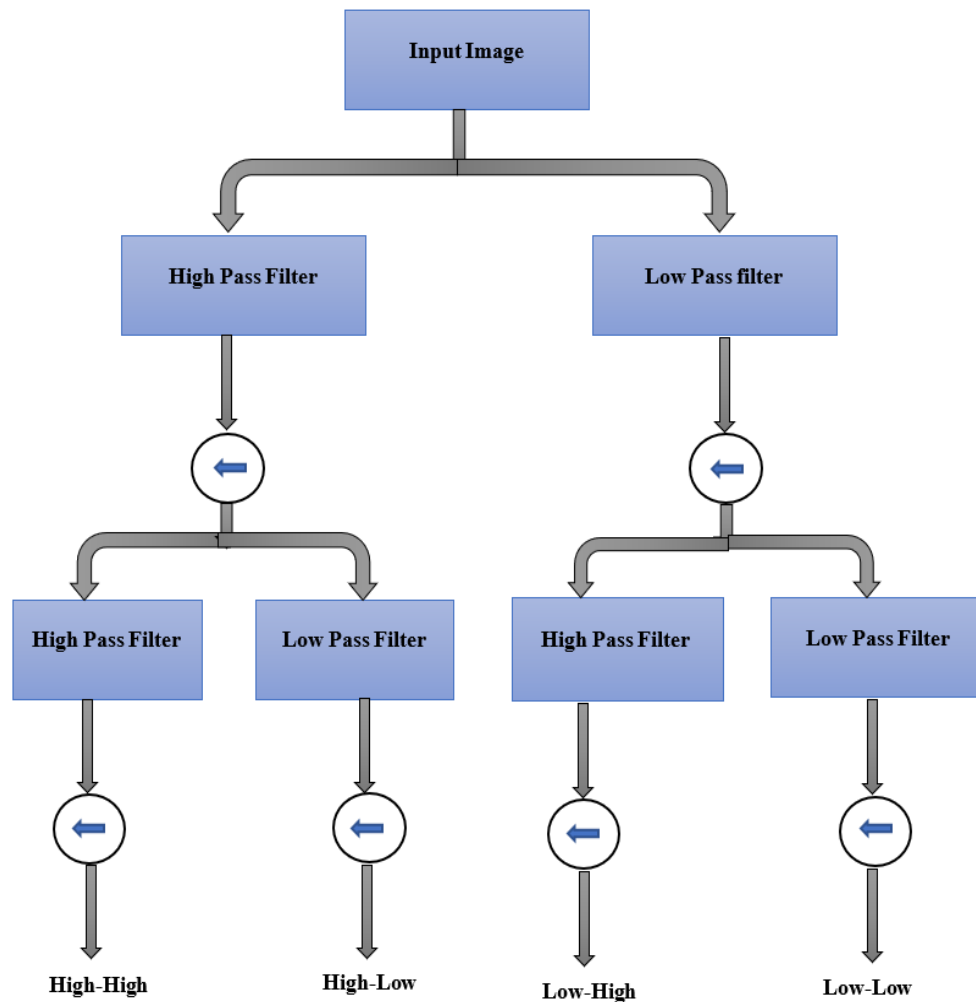


Figure 2: Architecture of Wavelet Transform

A common Discrete Wavelet Transform (DWT) equation is:

$$W(j, k) = \sum_n x(n) \psi_{j,k}(n) \quad (3)$$

where:

$W(j, k)$ represents the wavelet coefficient at scale j and position k ,

$x(n)$ is the input signal (image intensity values),

$\psi_{j,k}(n)$ is the wavelet basis function at scale j and position k .

This transformation enables multi-resolution analysis, improving anomaly detection accuracy in medical images.

4.5 Particle Swarm Optimization

Particle swarm Optimization is a population-based optimization algorithm which is inspired from collective behavior of birds and fishes. In medical anomaly detection, it helps in optimizing feature selection and hyperparameters by improving candidate solution iteratively on the bases of fitness. In this way every particle adjusts its position for movement in search space considering itself as the best-known position found for swarm to come out with best possible convergence response.

A standard PSO position update equation is:

$$\begin{aligned} v_i^{(t+1)} &= wv_i^{(t)} + c_1r_1(p_i - x_i^{(t)}) + c_2r_2(g - x_i^{(t)}) \\ x_i^{(t+1)} &= x_i^{(t)} + v_i^{(t+1)} \end{aligned} \quad (4)$$

where:

$v_i^{(t)}$ is the velocity of particle i at iteration t ,

$x_i^{(t)}$ is the current position of particle i ,

p_i is the particle's best-known position,

g is the global best position found by the swarm

w is the inertia weight,

c_1 and c_2 are acceleration coefficients,

r_1 and r_2 are random values in the range $[0,1]$.

This approach enhances the efficiency of medical anomaly detection by optimizing feature selection and classification model parameters.

5.Results and Discussion

This framework uses Wavelet Transform (WT) to extract the important features, whereas Particle Swarm Optimization (PSO) is used for optimal feature selection. Thus, integrating WT and PSO achieves the desired level of accuracy in medical abnormality detection. Performance evaluation in terms of sensitivity, specificity, and minimal false discovery rate has been undertaken. The cloud approach guarantees secure data storage, real-time processing, and scalability. Hence, the system is superior to conventional methods insofar as automatic medical anomaly detection is concerned.

Performance Metrics

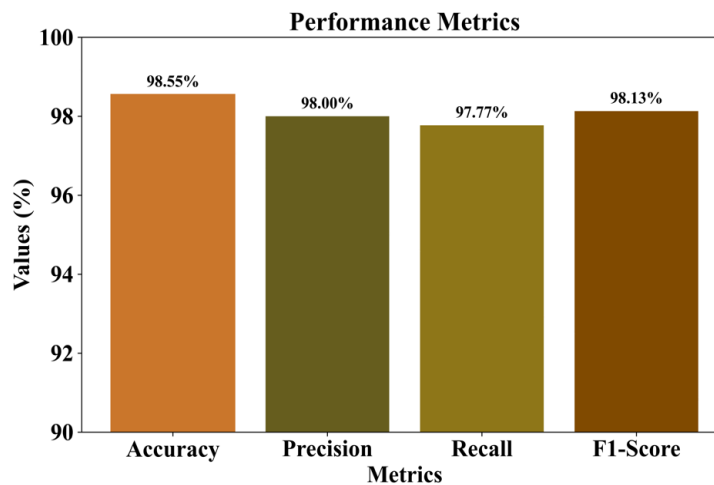


Figure 3: Performance Metrics

In Figure 3, The offered anomaly detection system is represented by Accuracy, Precision, Recall, and F1-Score through the proper bar chart. The system shows an accuracy of 98.55%, precision of 98.00%, recall of 97.77%, and an f-measure of 98.13%, which validates the system's reliability in detecting medical anomalies. The performance has been balanced for all metrics, suggesting effectiveness in minimizing both false positives and false negatives. Such results suggest that the proposed technique is strong on automated medical anomaly detection.

Latency

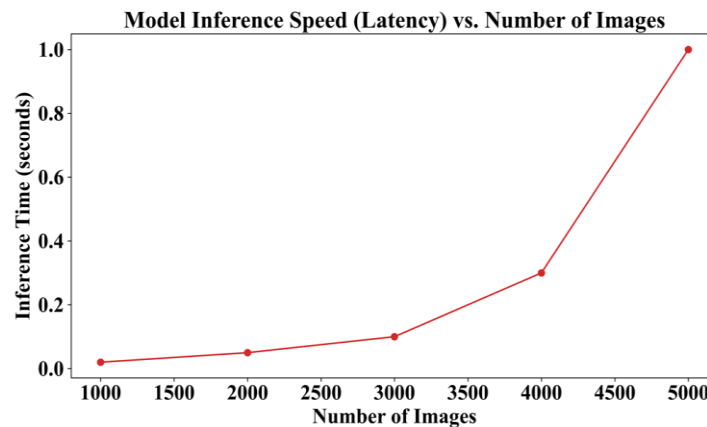


Figure 4: Latency

Figure 4 represents inference speed (latency) by number of processed images. The increase in images processed results in an increment in inference time, but surges significantly after crossing the 4000 marks, which demonstrates increasing computational overhead. It appears that for smaller datasets, the model is efficient, but with an increase in size, the latency overall increases. Thus, optimization is needed in medical anomaly detection for larger scales.

Speed

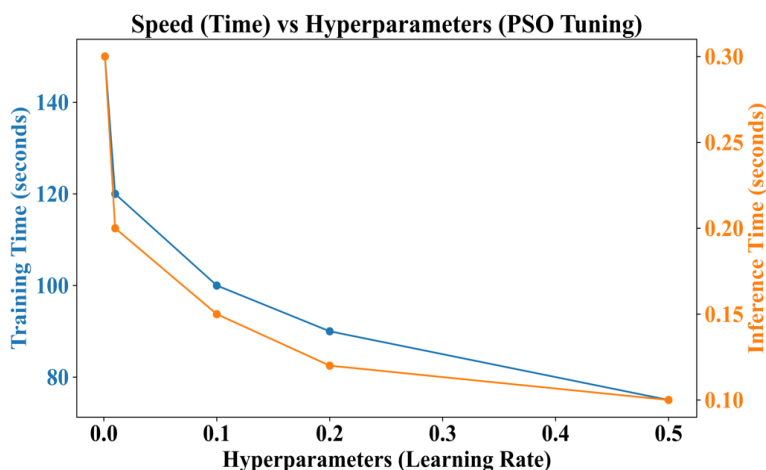


Figure 5: Hyperparameter Tuning

Figure 5 shows an illustrative one regarding the training time vs. inference time vs. learning rate, for models during PSO-based tuning up of hyperparameters. A large decrease in training time (blue line) and inference time (orange line) are observed when the learning rate is increased from 0.0 to 0.5; hence, the optimization efficiency

is increased. The convergence is faster at a high learning rate, for which computation overhead is minimized. This is evidence that PSO tuning proves effective in speed and model performance balancing.

6. Conclusion

The designed cloud-integrated wavelet transforms and particle swarm optimization framework improves performance in automated anomaly detection for medical imaging by guaranteed accuracy and computational efficiency. Specific feature extraction is made possible using wavelet transform, while the hyperparameter optimization of the model leads to excellent classification performance under the particle swarm optimization algorithm. Experimentally high accuracy with fewer wrong detections and rapid inference speed has been exhibited. A cloud approach will also ensure scalability, security, and real-time processing, hence a reliable solution for medical anomaly detection.

Reference

1. Kwon, D., Hodkiewicz, M. R., Fan, J., Shibutani, T., & Pecht, M. G. (2017). IoT-based prognostics and systems health management for industrial applications. *IEEE access*, 4, 3659-3670.
2. Franklin, A., Gantela, S., Shifarrar, S., Johnson, T. R., Robinson, D. J., King, B. R., ... & Okafor, N. G. (2017). Dashboard visualizations: Supporting real-time throughput decision-making. *Journal of biomedical informatics*, 71, 211-221.
3. Islam, S. R., Kwak, D., Kabir, M. H., Hossain, M., & Kwak, K. S. (2015). The internet of things for health care: a comprehensive survey. *IEEE access*, 3, 678-708.
4. Kumarage, H., Khalil, I., Alabdulatif, A., Tari, Z., & Yi, X. (2016). Secure data analytics for cloud-integrated internet of things applications. *IEEE Cloud Computing*, 3(2), 46-56.
5. Li, K. F. (2013). Smart home technology for telemedicine and emergency management. *Journal of Ambient Intelligence and Humanized Computing*, 4, 535-546.
6. ElShafee, A. (2015). Towards an Affordable Real-Time Cardiovascular Emergency Detection and Response System. *International Journal of Computer Applications*, 118(11).
7. Andreu-Perez, J., Leff, D. R., Ip, H. M., & Yang, G. Z. (2015). From wearable sensors to smart implants—toward pervasive and personalized healthcare. *IEEE Transactions on Biomedical Engineering*, 62(12), 2750-2762.
8. Bongiani, M., Orrù, C., Groveman, B. R., Sacchetto, L., Fiorini, M., Tonoli, G., ... & Zanusso, G. (2017). Diagnosis of human prion disease using real-time quaking-induced conversion testing of olfactory mucosa and cerebrospinal fluid samples. *JAMA neurology*, 74(2), 155-162.
9. Clotet, R., Hernández, E., Huerta, M., & Rivas, D. (2015). Ecosystem of Electronic Health Record Databases in Venezuela. In *VI Latin American Congress on Biomedical Engineering CLAIB 2014, Paraná, Argentina 29, 30 & 31 October 2014* (pp. 809-812). Springer International Publishing.
10. Yang, H., Kundakcioglu, E., Li, J., Wu, T., Mitchell, J. R., Hara, A. K., ... & Tsui, K. L. (2014). Healthcare intelligence: turning data into knowledge. *IEEE Intelligent Systems*, 29(3), 54-68.
11. Gulgec, N. S., Shahidi, G. S., Matarazzo, T. J., & Pakzad, S. N. (2017). Current challenges with bigdata analytics in structural health monitoring. In *Structural Health Monitoring & Damage Detection, Volume 7: Proceedings of the 35th IMAC, A Conference and Exposition on Structural Dynamics 2017* (pp. 79-84). Springer International Publishing.
12. Alexander, C. A., & Wang, L. (2017). Big data analytics in heart attack prediction. *J Nurs Care*, 6(393), 2167-1168.
13. Vijayarani, S., & Jothi, M. P. (2014). Hierarchical and partitioning clustering algorithms for detecting outliers in data streams. *International J. of Advanced Research in Computer and Communication Engineering*, 3(4), 6205-6207.
14. Bedi, G. S., & Singh, A. (2014). Big Data Analysis with Dataset Scaling in Yet another Resource Negotiator (YARN). *International Journal of Computer Applications*, 92(5).
15. Taghavifar, H., Khalilarya, S., & Jafarmadar, S. (2014). Diesel engine spray characteristics prediction with hybridized artificial neural network optimized by genetic algorithm. *Energy*, 71, 656-664.
16. Akbar, A., Khan, A., Carrez, F., & Moessner, K. (2017). Energy Efficient Approach for M2M Networks Using Cloud-Based 6LoWPAN Testbed; JIoT Oct. 2017 1787-1797 Al-Kashoash, HAA, Hafeez, M., and Kemp, AH, Congestion Control for 6LoWPAN Networks: A Game Theoretic Framework; JIoT June 2017. *IEEE Internet of Things Journal*, 4(6), 2363.
17. Katsaros, K., & Dianati, M. (2016). A conceptual 5G vehicular networking architecture. In *5G Mobile Communications* (pp. 595-623). Cham: Springer International Publishing.

18. Ahmadianfar, I., Adib, A., & Salarijazi, M. (2016). Optimizing multireservoir operation: hybrid of bat algorithm and differential evolution. *Journal of Water Resources Planning and Management*, 142(2), 05015010.
19. Alnuem, M., Alrumaih, H., & Al-Alshaikh, H. (2015). A comparison study of information security risk management frameworks in cloud computing. *Cloud computing*, 103-109.
20. Rass, S., Benjamin, R., & Schauer, S. (2013). On the practical feasibility of secure multipath communication. *International Journal of Advanced Computer Science and Applications*, 4(10).
21. Li, Z., Itakura, K. I., & Ma, Y. (2014). Survey of measurement-while-drilling technology for small-diameter drilling machines. *Electronic Journal of Geotechnical Engineering*, 19(2), 10267-10282.
22. Shahadat, N., Rahman, M., Ahmed, S., & Rahman, B. (2017, September). Predicting higher secondary results by data mining algorithms with VBR: A feature reduction method. In *2017 4th International Conference on Advances in Electrical Engineering (ICAEE)* (pp. 164-169). IEEE.
23. Ahmad, I., Bakht, H., & Mohan, U. (2017). Cloud Computing—Threats and Challenges. *J. Comput. Manag. Stud*, 1(1).
24. Qiu, S., Xu, G., Ahmad, H., & Wang, L. (2017). A robust mutual authentication scheme based on elliptic curve cryptography for telecare medical information systems. *IEEE access*, 6, 7452-7463.
25. Ravi, V., & Kamaruddin, S. (2017). Big data analytics enabled smart financial services: opportunities and challenges. In *Big Data Analytics: 5th International Conference, BDA 2017, Hyderabad, India, December 12-15, 2017, Proceedings 5* (pp. 15-39). Springer International Publishing.