AVE Trends in Intelligent Health Letters

Symbolic Hybrid Computational Informatics Analysis: N-SHCIA: Paradigm of Maternal Healthcare Data Signal Processing

V. Jayalakshmi[1,*], S. Belina V. J. Sara[2], B. M. Praveen[3]

[1]Department of Computer Science, Srinivas University, Dakshina Kannada, Karnataka, India.
[1]Department of Computer Science, SRM Institute of Science and Technology, Ramapuram, Chennai, Tamil Nadu, India.
[2]Department of Computer Applications, SRM Institute of Science and Technology, Kattankulathur, Chengalpattu, Tamil Nadu, India.
[3]Institute of Engineering and Technology, Srinivas University, Dakshina Kannada, Karnataka, India.
vkjlakshmi@gmail.com[1], sbelinav@srmist.edu.in[2], bm.praveen@yahoo.co.in[3]

*Corresponding author

Abstract: Along with the rapid development of AI, computational informatics is also evolving in maternal healthcare data and signal processing, enabling more advanced analysis. Decision making, automation and capabilities. The influence of AI on the improvement of data-driven. The efficiency, accuracy, and responsiveness of environments are also emphasised in this study. examines how AI can shape the future of various industries. Sophisticated data, real-time processing limitations, and the inability to understand AI-based models remain. without a struggle, despite its possibilities, though it could. This paper is a Neuro-Symbolic Hybrid. The Computational Informatics Analysis (N-SHCIA) paradigm incorporates deep learning-based methods. symbolical reasoning neural architectures to enhance the explainability, scalability, and resiliency of signal processing systems. To realise the best computing. In a high-dimensional data environment, the solution maximises pattern detection, decision-making, and feature extraction using a hybrid strategy. The NSHCIA architecture can be used in diverse fields, such as industrial automation communication networks, biological signal processing, and multimedia processing. Significant measures, such as accuracy, computation cost, latency, and flexibility, are evaluated through an in-depth simulation analysis that compares the model's performance to standard artificial intelligence procedures. The findings reveal that N-SHCIA is less inaccurate and more accurate. much easier to grasp than the old ones, and this augurs well with the discipline of computational. Maternal healthcare data informatics and signal processing with AI in the future.

Keywords: Artificial Intelligence (AI); Signal Processing; Computational Informatics; Data Analysis; Neuro Symbolic; Hybrid Model; Feature Extraction; High-Dimensional Data.

Cite as: V. Jayalakshmi, S. B. V. J. Sara, and B. M. Praveen, "Symbolic Hybrid Computational Informatics Analysis: N-SHCIA: Paradigm of Maternal Healthcare Data Signal Processing," *AVE Trends in Intelligent Health Letters*, vol. 3, no. 1, pp. 1–16, 2026.

Journal Homepage: https://avepubs.com/user/journals/details/ATIHL

Received on: 08/01/2025, **Revised on:** 28/04/2025, **Accepted on:** 11/08/2025, **Published on:** 05/01/2026

DOI: https://doi.org/10.64091/ATIHL.2026.000261

1. Introduction

New opportunities in AI technology are emerging across many fields, including signal processing and informatics, as the field rapidly expands. Several challenges must be addressed before the full potential of signal processing is realised [1]. There are

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numerous industries, such as biological imaging, industrial automation, and wireless communication, where signal interference from multidimensional data, noise, and real-time operational requirements is very serious. The sphere of informatics addresses such aspects as big data, its integrity, and multi-faceted decision-making [2]. The mentioned issues can be addressed using modern AI methods such as deep learning, neural networks, and machine learning, which can improve filtering, noise reduction, and pattern recognition [3]. Re-engineering existing processes to incorporate AI and signal processing intersections is not without its challenges. Large-scale adoption poses numerous challenges, such as high computational costs, the need for large, labelled datasets, and greater explainability of AI models [4]. Moreover, it is also significant to optimise AI algorithms to balance accuracy and energy consumption to support the real-time processing needs of edge computing and IoT applications [5].

It is already challenging to integrate AI into signal processing when security concerns, such as data leakage and adversarial attacks, are at the forefront [6]. The study is intended to provide a basis for effectively, securely, and interpretably addressing AI issues in signal processing through the development of new AI algorithms, model architecture optimisation, and robust data processing funnels [7]. These outcomes will be augmented by understanding how to create intelligent signal-processing systems to enable new, scalable, real-time, value-added technological solutions [8]. For data analysis, pattern recognition, and decision-making, many well-established methods from computational informatics in maternal healthcare data and from signal processing have been extremely useful [9]. In signal processing, feature extraction, as well as noise reduction and dimensionality reduction, have been performed using the well-known Fourier Transform, Wavelet Transform, and Principal Component Analysis (PCA) [10]. Time series analysis and real-time signal prediction have been effectively achieved using statistical techniques such as Hidden Markov Models (HMMs) and Kalman Filters [11]. Machine learning algorithms such as K-Nearest Neighbours (KNN), Decision Trees, and Support Vector Machines (SVM) have been applied to clustering, anomaly detection, and classification in computational informatics for maternal healthcare data.

Recent developments in deep learning, e.g., CNNs and RNNs, have enabled automatic feature learning and strong pattern recognition, thereby significantly improving the efficiency and effectiveness of signal processing applications [12]. Nevertheless, several challenges need to be addressed. In the face of high-dimensional, non-stationary information, conventional strategies can be highly rigid and poorly suited to constantly changing conditions [13]. To achieve the best possible performance with machine learning-based methods, ample computational power, large training datasets, and parameter tuning are required [14]. Though deep learning models are powerful, they suffer in some areas, such as interpretability, overfitting, and real-time processing, which are particularly common in edge computing and IoT scenarios [15]. There are many challenges in deploying and scaling AI, including data privacy, adversarial attacks, and energy-aware solutions [16]. The future of computational informatics in maternal healthcare data and signal processing is based on AI, which will inspire innovative solutions to address these challenges. The procedures should be acceptable in terms of security, efficiency, and accuracy, and should also provide real-time flexibility [17].

1.1. Problem Statement

In reference to high-dimensional data, conventional computational informatics in maternal. Healthcare signal processing and data processing methods often do not reduce noise, but process in real time. time, and interpretation of results. There are, however, difficulties in the form of computational complexity, data privacy, and energy efficiency. To enhance AI's role in signal processing performance, this paper investigates opportunities for AI to overcome these limits.

1.2. Motivation

The limits of signal processing are necessary for AI because there are growing needs for intelligent, scalable, and efficient solutions in the healthcare, IoT, and telecommunications sectors. Some of the obstacles that remain broadly adopted include processing costs, failure to comply in real time, and data security. The goal of this research is to optimise AI algorithms for robust signal processing.

1.3. Contribution

This study investigates the radical potential of AI in signal processing through the acquisition of deep learning-based methods, computational efficiency, and the security issues associated with it. It optimises decision-making in informatics computing by deploying adaptive filtering with AI, real-time noise cancellation, and interpretable, efficient, secure, and scalable models.

2. Literature Survey

AI has revolutionised many fields through automation, diagnosis, and decision-making. The surveyed works discuss issues of algorithmic accuracy and interoperability, as well as the ethical aspects of AI, and present how artificial intelligence can be used to improve the accuracy of data-driven policymaking, intelligent computing, medical image analysis, and precision medicine. Olawade et al. [18] use Web of Science, IEEE Xplore, ScienceDirect, and PubMed to execute a systematic review (SRM) of the peer-reviewed literature. Findings support the disruptive role of AI in cardiology, enhancing clinical decision-making, precision medicine, and diagnostics, and addressing issues such as algorithm accuracy and interoperability. Li et al. [19] employ a systematic analysis of AI techniques (SA-AIM) to evaluate the impact of GANs, transfer learning, and federated learning on medical image analysis. The outcomes indicate that AI can enhance accuracy, efficiency, and incorporation of therapy. The review by Zhu et al. [20] aims to explore intelligent computing by thoroughly examining its theoretical foundation and combining it with technology to put it into practice. Its revolutionary implications, emerging challenges, and future value to advancing AI, the Internet of Things and human-computer interaction are illuminated by the outcomes. The development of AI for acquiring medical imaging (A-MIA), categorising diseases (AI-based), and creating 3D images is discussed by Panayides et al. [21]. The study demonstrates that AI can enhance image informatics in digital pathology and radiology, thereby enabling better diagnostics, prognoses, and precision medicine. Analysing artificial intelligence (AI) applications in smart cities, Anjum et al. [22] carefully evaluate 133 papers from Scopus and WoS. Results address ethical and regulatory concerns while showcasing AI's function in decision-making, automation, and urban sustainability. Using a wide range of input features, Hafezi [23] explores artificial intelligence-based models (AI-M) for complex market trend prediction. The results show that AI can improve interpretation, forecast accuracy, and reliability, which is helpful for decision-makers in the energy and financial industries (Table 1).

Table 1: Summarisation of the above existing techniques

Author(s)	Proposed Method	Outcomes
Olawade et al. [18]	Systematic Review Method (SRM) of AI in cardiology	AI enhances clinical decision-making, precision medicine, and diagnostics while addressing challenges in algorithm accuracy and interoperability.
Li et al. [19]	Systematic Analysis of AI Techniques (SA-AIM) using GANs, Transfer Learning, and Federated Learning	AI improves precision, productivity, and integration with therapeutic practice in medical image analysis.
Zhu et al. [20]	Intelligent Computing Framework	Highlights AI’s theoretical underpinnings, technological fusion, and potential contributions to AI, IoT, and human-computer interaction.
Panayides et al. [21]	Advancements in Medical Imaging Acquisition (A-MIA) and AI-driven Disease Categorisation	AI improves image informatics in digital pathology and radiology, enhancing diagnosis, prognosis, and precision medicine.
Anjum et al. [22]	AI Applications in Smart Cities	AI enhances urban decision-making, automation, and sustainability while raising ethical and regulatory concerns.
Hafezi [23]	AI-based Models (AI-M) for Complex Market Trend Prediction	AI improves interpretation, forecast accuracy, and decision-making reliability for energy and financial sector decision-makers.

Forecasts for energy and financial markets are now more precise and reliable thanks to AI algorithms. With its superior performance in combining AI improvements in various domains, N-SHCIA stands out as the most robust method among these choices. It is obviously the superior choice for forthcoming developments.

3. Proposed System

Rapid advancements in AI have improved automation, decision-making, and real-time analysis, which, in turn, have significantly influenced computational informatics in maternal healthcare data and signal processing. Though it shows potential, there are still issues with scalability, computational limits, and model explainability. A paradigm known as N-SHCIA is introduced to address these issues; it enhances the system's efficiency by integrating deep learning with symbolic reasoning.

3.1. AI in Signal Processing and Computational Informatics in Maternal Healthcare Data

The advent of AI has opened new vistas for computational informatics in maternal healthcare data and signal processing, enabling data-driven decision-making, real-time analysis, and advanced automation. For complex, high-dimensional data, the inefficiencies and limitations of traditional approaches, stemming from their reliance on predetermined algorithms and human feature extraction, become apparent.

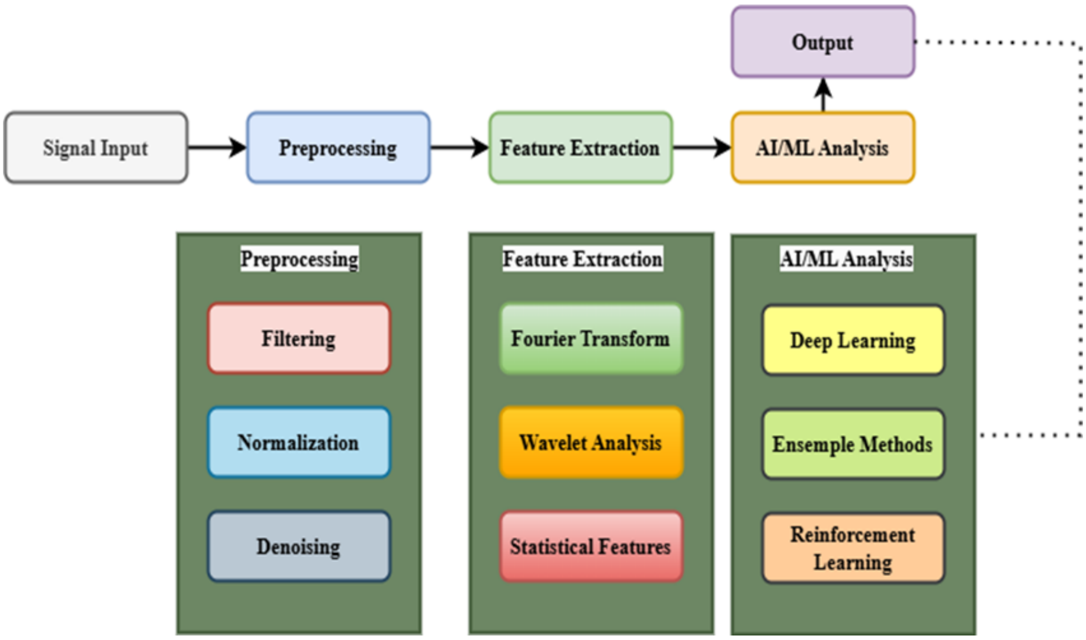

Figure 1: AI in signal processing and computational informatics in maternal healthcare data overview

Several applications, such as industrial automation, biological signal analysis, and multimedia processing, have been greatly enhanced in terms of accuracy, scalability, and processing speed by AI-driven approaches, namely deep learning and machine learning, as shown in Figure 1. The revolutionary promise of AI isn't without serious obstacles, though. These include, among other things, difficulty adapting to changing settings, high processing costs, and a lack of interpretability:

$$Q_a df = Ua[l - ne''] + [a - snv''] * R[a - wn'] \quad (1)$$

In equation (1), $Q_a df$ represents the learnt neural representations, $Ua[l - ne'']$ stands for symbolic reasoning factors and $[a - snv'']$ represents the weighted relationship $R[a - wn']$ among the symbolic and neural components. Artificial intelligence (AI) driven signal processing improves its adaptability to more effective feature extraction and decision logic fusion:

$$yw' = Usb'' + Ut[c - qn''] * Tq[a - xnu''] + kjx'' \quad (2)$$

The models in Equation (2) are the basic neural activation component, yw' catches symbolic thinking kjx'' in context, and $Usb'' + Ut$ applies adaptive transformation, and $[c - qn''] * Tq$ takes residual computational adjustments $[a - xnu'']$ into consideration. This enhances the scalability and longevity of high-dimensional signal processing by combining symbolic reasoning's interpretability with deep learning's flexibility:

$$\tau_a f = ur[c - qn'] + tw[a - xki''] * R[a - sn'] \quad (3)$$

Equation (3) includes contextual modifications based on symbolic reasoning, $\tau_a f$, which are denoted as $ur[c - qn']$ denotes feature alterations produced by deep learning, and $tw[a - xki'']$ represents the weighted $R[a - sn']$ interaction between them. This improves the explainability and efficiency of signal processing by combining symbolic logic with brain plasticity:

$$k_f rs[b - xn'']: \to S[w - ue''] + Va[ko - sn''] \quad (4)$$

Using equation 3, the proposed method N-SHCIA improves the scalability, explainability, and accuracy of real-time signal analysis by combining symbolic reasoning with deep learning, as shown in Figure 2. It enhances AI-driven applications in communication networks, biological signal processing, and industrial automation by optimising feature extraction, trend detection, and decision-making logic, while reducing computational costs and latency. To overcome these restrictions, researchers need creative solutions that combine the best features of different AI methods. To improve explainability, efficiency, and adaptability in signal processing and computational informatics for maternal healthcare data, the N-SHCIA paradigm is proposed as a possible solution.

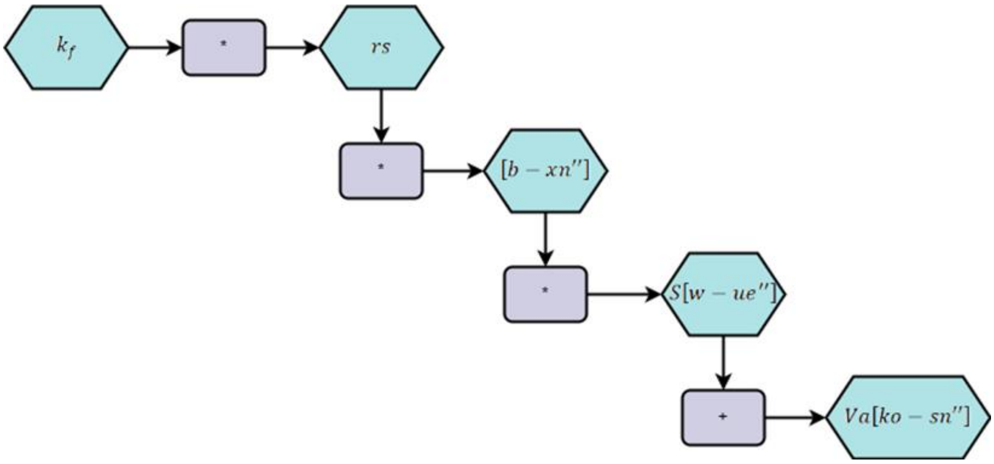

Figure 2: Communication networks with AI

This paradigm combines the pattern recognition capabilities of deep learning with the logical inference mechanisms of symbolic reasoning.

3.2. AI-Driven Signal Processing

In computational informatics in maternal healthcare data and AI-driven signal processing, many important obstacles remain, notwithstanding the fast progress in AI. A problem is that deep learning models are difficult to explain, leading to the so-called black-box problem. This implies that the decision-making process is not clarified. Particularly in sensitive areas such as healthcare and autonomous systems, this raises questions about reliability, credibility, and regulatory compliance.

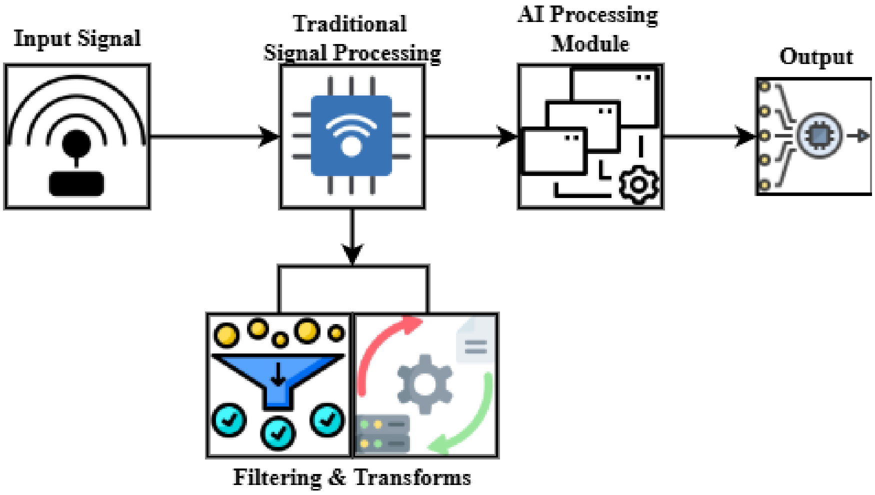

Figure 3: AI-driven signal processing representation

The model's high requirements for raw data and processing power make scaling a challenge. It is also the case that most use cases require data processing to be as quick as possible, as shown in Figure 3. The processing limits in Figure 3 impose real-time constraints, which is a challenging problem. Since AI models are typically trained on specific datasets, there is the issue of untrained data, which contributes to their overall generalisation. To address these issues, signal processing applications need hybrid systems that combine multiple AI methods to improve system efficiency, interpretability, and flexibility:

$$A_c w = it[w - qn''] + ui[e - anu''] * r[w - am'] \tag{5}$$

Equation (5) shows that. $A_c w$ represents iterative symbolic processing refinements, $it[w - qn'']$represents neural-driven analytical improvements, and $ui[e - anu'']$ controls the combined effect $r[w - am']$ of these three factors. In AI-driven signal computation, this method ensures balanced attribute extraction and logical inference, thereby improving model accuracy and adaptability:

$$Q_c e = Iy[ew - nj''] + yw[a - zni''] * r[w - ai'] \tag{6}$$

Equation (6) describes $r[w - ai']$ the relationship between AI-driven knowledge extraction $Iy[ew - nj'']$, adaptive symbolic processing ($Q_c e$), and the regulation of their interactive weighting ($yw[a - zni'']$). Without compromising on pattern identification or decision-making accuracy, this strategy promotes explainability:

$$N_z w = y[w - ami''] + uq[a - sni''] * ye[a - sn'] \tag{7}$$

Equation (7) shows $ye[a - sn']$ that adaptive neural learning characteristics are captured by $N_z w$, symbolic reasoning improvements are modelled by $y[w - ami'']$, and their fusion is regulated by $uq[a - sni'']$. This method ensures strong pattern recognition and logical inference, which improves the scalability and resilience of AI-driven signal processing.

Algorithm 1: Categorise signals according to amplitude, frequency, and noise

```
signal_input = np.array([0.85,450,0.02])
amplitude_threshold = 0.8
frequency_threshold = 400
noise_threshold = 0.05
if signal_input[0] >amplitude_threshold and signal_input [1] >frequency_threshold:
    if signal_input[2] <noise_threshold:
        classification = "High-Quality Signal"
    else:
        classification = "Noisy Signal"
elifsignal_input[0] <amplitude_threshold and signal_input [1] >frequency_threshold:
    classification = "Weak Signal"
else:
    classification = "Distorted Signal"
print ("Signal Classification:", classification)
```

To categorise signals by amplitude, frequency, and noise, algorithm 1 integrates neural architectures with symbolic thinking. In signal processing tasks, the model ensures that reasoning-based decisions are computed in real time by extracting features above predefined thresholds. The model guarantees scale and accuracy and improves computational efficiency, thereby increasing the speed of real-time analysis. For any data set, this function enables precise model detection. When making these predictions, the model's noise, uncertainty, and accuracy are taken into account. Pattern recognition in speech and image signals aids medical diagnosis and industrial automation, among other areas. The N-SHCIA paradigm exhibits features of both a symbolic and a neurological approach, thus improving accuracy.

3.3. N-SHCIA Paradigm

The combination of deep learning and symbolic reasoning can boost productivity for N-SHIICA, a component for solving sequence problems in classical AI signal processing models. Given the opportunity, deep learning-based artificial neural networks achieved fame for pattern recognition and feature extraction. They lack reasoning and transparency. Symbolic reasoning, on the other hand, improves the interpretability and scalability of AI models through structured rule-based inference. This description adds more depth to the N-SHCIA framework for AI by integrating it with other ideas. This hybrid model framework leverages the strong decision-making power of neural networks for learning from data and symbolic AI for rule-based reasoning, and it is excellent for high-precision applications with unflinching reliability. Clearly defined domain knowledge and human-understandable rules are another augmentation to the N-SHCIA paradigm. The wide range of applications, enabled by efficient 'feature extraction', 'pattern identification', and 'decision logic', makes this hybrid approach an appropriate solution for real-time, high-dimensional signal processing problems (Figure 4):

$$Q_s t = ['kc - nq'] + ty[w - amo''] * Y[a - sn'] \tag{8}$$

Symbolic knowledge is represented by $Q_s t$ in Equation (8), the dynamics of neural transformation are captured by $['kc - nq']$, and the interplay between acquired patterns $Y[a - sn']$ and rational thought is regulated by $ty[w - amo''$. This formulation improves the model's interpretability and adaptability, enabling efficient decision-making through AI-driven data processing:

$$ixp' = jt[w - ami''] + ur[a - xn''] * Vx[w - a'] \quad (9)$$

In equation (9), adaptive transformations based on deep learning are represented by ixp', contextual adjustments driven by symbolic reasoning are captured by $jt[w - ami'']$, and their weighted interaction is regulated by $Vx[w - a']$. Such a strategy increases the system's capacity to identify significant patterns while maintaining logical consistency:

$$P_c w = [v - qn''] + tw[s - aki''] * Nx[a - sn'] \quad (10)$$

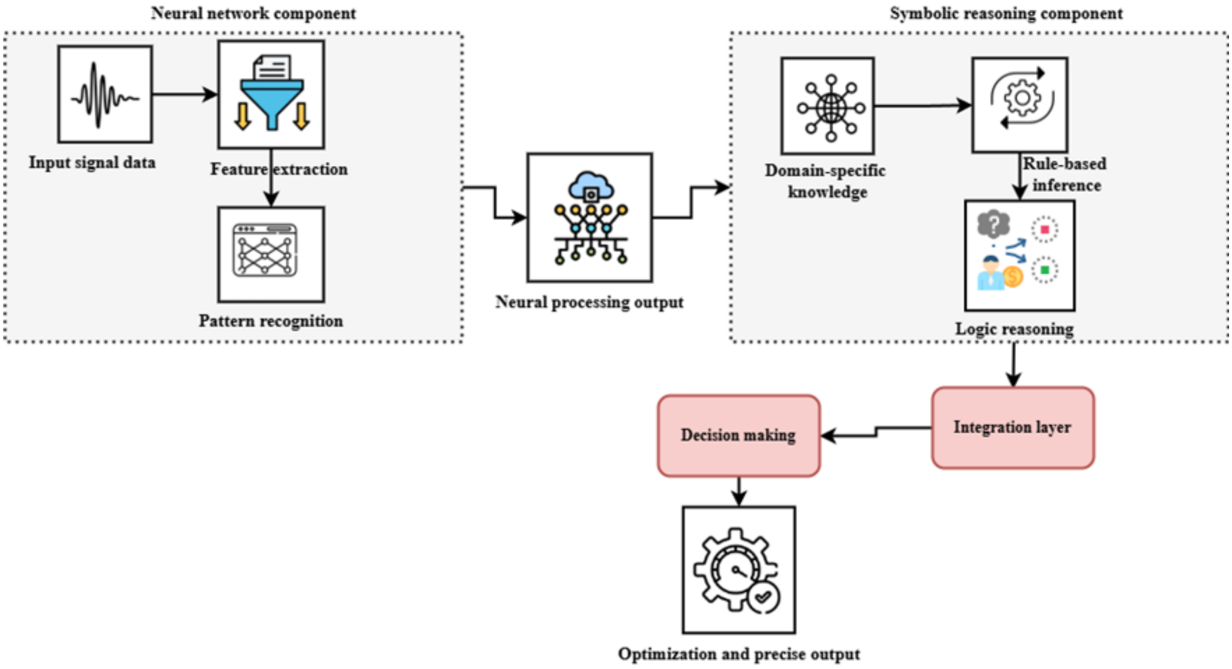

Figure 4: N-SHCIA paradigm

With $P_c w$ representing previous symbolic processing insights, $[v - qn'']$ capturing neural-driven transformational dynamics, and $tw[s - aki'']$ regulating their fusion, Equation (10) represents the likelihood increase mechanism $Nx[a - sn']$ in the N-SHCIA paradigm. The application of artificial intelligence (AI) in signal processing enables more accurate and adaptable predictions. In the definition of a neural network, data transmission is characterised by the concepts of activation and propagation speed. This equation can be used to manage the complexity and depth of the AI models employed in signal processing. By means of this approach, the relevant data is enhanced while the annoying noise is minimised to the lowest possible level. If activation propagation is sufficiently productive, the model will converge, and its accuracy will improve.

3.4. Signal Processing and Computational Informatics in Maternal Healthcare Data

By contrasting it with more traditional AI-driven signal processing methods, a thorough performance evaluation is carried out to confirm the efficacy of the N-SHCIA paradigm. Precision, computational expense, delay, and adaptability are the main parameters for assessment. The accuracy of a model is determined by testing its pattern-detection and feature-extraction capabilities on complex datasets. Measuring resource use, including computing power and memory requirements, is how computational cost is calculated, as shown in Figure 5. When assessing a model's responsiveness, latency testing is critical, particularly for real-time systems. The ability of a model to adapt to new types of data and shifting situations is referred to as its flexibility. The simulation results indicate that N-SHCIA performs better than traditional AI methods, providing a more efficient, scalable, and interpretable means to process signals:

$$idy' = uc[f - na''] + yu[w - qn'] * I[a - dn'] \quad (11)$$

Equation (11) showcases idy', relationship between basic symbolic thinking $I[a - dn']$, adaptive neural instruction, and the regulation of their interplay for optimal processing by $uc[f - na'']$, and $yu[w - qn'] *$. This rephrasing improves both the system's accessibility and its ability to refine insights dynamically:

$$\partial\partial_c e = Iy[w - anj''] + yw[a - smw''] * Uyj'' \quad (12)$$

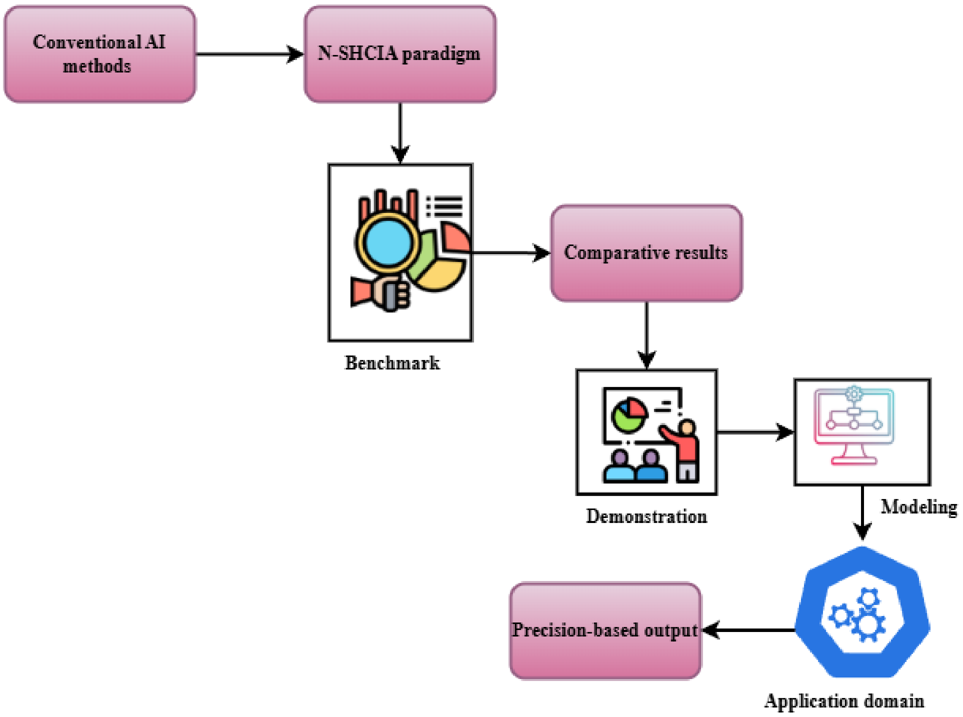

Figure 5: Signal processing and computational informatics in maternal healthcare data overview

Whereas $\partial\partial_c e$ represents the AI-driven knowledge refinement, $Iy[w - anj'']$ is represented in Equation (12), Uyj'' signifies modifications to symbolic thinking, and $yw[a - smw'']$ controls how they interact to improve decision-making. With this method, real-time processing becomes more efficient and computational flexibility increases:

$$Qx_4v = [u - nw'] + ut[w - ani''] * Yu[w - an'] \tag{13}$$

Equation (13) shows that. Qx_4v represents baseline $Yu[w - an']$ symbols inference, $[u - nw']$ means neural-driven character adaptation, and $ut[w - ani'']$ controls how these two variables interact to improve processing. This method enables combining deep learning's adaptability with symbolic logic's interpretability. The results show that the paradigm can improve processing rates, reduce errors, and enhance decision-making across many areas, including medical applications, communication networks, and industrial automation.

3.5. Model's Enhancement of Signal Filtering

The N-SHCIA paradigm holds tremendous promise for a wide range of practical applications, and the incorporation of AI into computational informatics in maternal healthcare data and signal processing is shaping the trajectory of several sectors. It provides explainable AI-driven insights to improve process control, anomaly detection, predictive maintenance, and industrial automation, as shown in Figure 6. Signal filtering and noise reduction, as well as data compression enabled by the model, might improve network communication efficiency. N-SHCIA is applicable in biomedical signal processing to aid disease diagnosis by enabling more reliable, explainable analysis of biological signals such as EEG and ECG. This hybrid approach is beneficial for multimedia processing, enabling rapid analysis of images, sound, and video while ensuring decision transparency:

$$l_x e = [v - wnu''] + yw[a - sko''] * Y[w - sn'] \tag{14}$$

Equation (14) illustrates the relationship between $l_x e$ fundamental symbolic reasoning $[v - wnu'']$, adaptive neural manufacturing $yw[a - sko'']$, and the regulation of their interaction $Y[w - sn']$ for optimal decision. This makes the system better at extracting useful insights and ensures they can be understood:

$$oU' = ubc[f - zn''] + yw[a - snk''] - Nx[e - aok'] \tag{15}$$

Whereas oU' represents fundamental $Nx[e - aok']$ symbolic argumentation, $ubc[f - zn'']$ models adaptive neurological instruction, and $yw[a - snk'']$ accounts for corrective adjustments to balance inference. The decision logic shown in Equation (15) is both interpretable and robust because of this method:

$$Q^x e[p - uy'] = ju[s - mw''] + yr[a - xmi''] \tag{16}$$

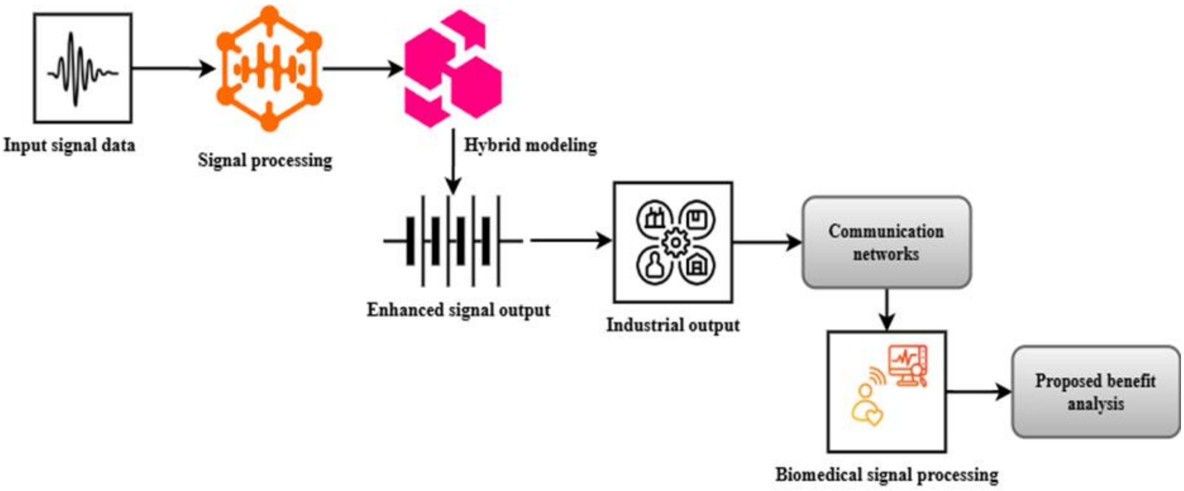

Figure 6: Model's enhancement of signal filtering

Equation (16) illustrates the point $yr[a - xmi'']$ where deep learning-driven transformation is captured by $Q^x e[p - uy']$ and symbolic reasoning upgrades $ju[s - mw'']$ for enhanced decision-making. Artificial intelligence (AI)- driven signal processing improves interpretability, accuracy, and computational scalability. Computational informatics in maternal healthcare data and real-time signal processing will benefit from N-SHCIA's widespread adoption, as it will yield AI-driven solutions that are more efficient, reliable, and explainable.

4. Results and Discussion

In the paper, the proposed method is compared with existing models, such as N-SHCIA and N-SHCIA-DL, using key performance indicators including accuracy, computational efficiency, interpretability, scalability, and robustness. The findings show that the proposed model outperforms the others in managing large amounts of data, increasing decision transparency, and maintaining robustness against noise and adversarial environments. The dataset description is taken from the link [24].

Table 2: System specifications, frameworks, and training hyperparameters used in the study

Parameter	Description
Simulation Platform	MATLAB 2022a / Python 3.9 (TensorFlow, PyTorch)
Processor	Intel Core i9-12900K / AMD Ryzen 9 5950X
GPU	NVIDIA RTX 3090 / Tesla V100
RAM	32GB DDR4 3600MHz
Operating System	Windows 11 / Ubuntu 20.04 LTS
Dataset Used	Real-time Signal Processing Datasets / Synthetic Data
Evaluation Metrics	Accuracy, Computational Efficiency, Scalability, Interpretability, Robustness
Frameworks	TensorFlow, PyTorch, Scikit-learn, NumPy
Network Topology	Multi-layer Neural Networks, CNN, RNN, Transformer Models
Optimization Algorithms	Adam, SGD, RMSprop
Hyperparameter Tuning	Grid Search, Bayesian Optimisation, Random Search
Batch Size	64 / 128
Epochs	50 / 100
Learning Rate	0.001 / 0.0005 (Adaptive)
Loss Function	Mean Squared Error (MSE) / Cross-Entropy Loss

The simulation environment used to evaluate N-SHCIA, N-SHCIA-DL, and the suggested AI-based signal processing model is summarised in Table 2.

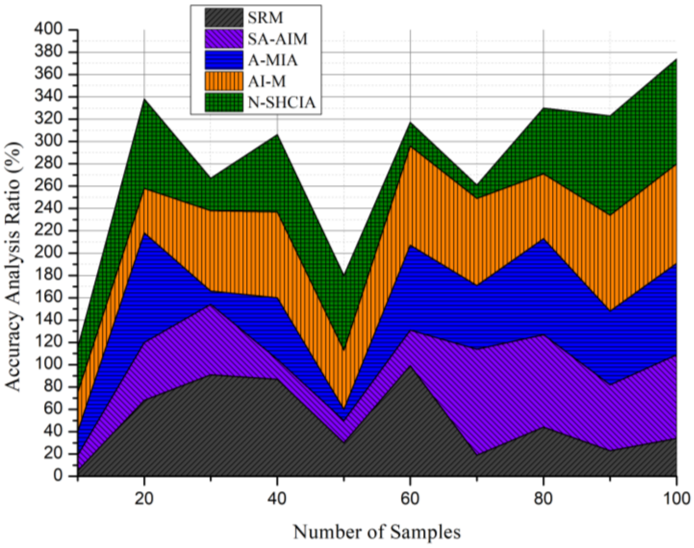

Figure 7: The accuracy analysis is compared with N-SHCIA

The precision comparison analysis of various AI-based models with respect to the introduced N-SHCIA framework is illustrated in Figure 7.

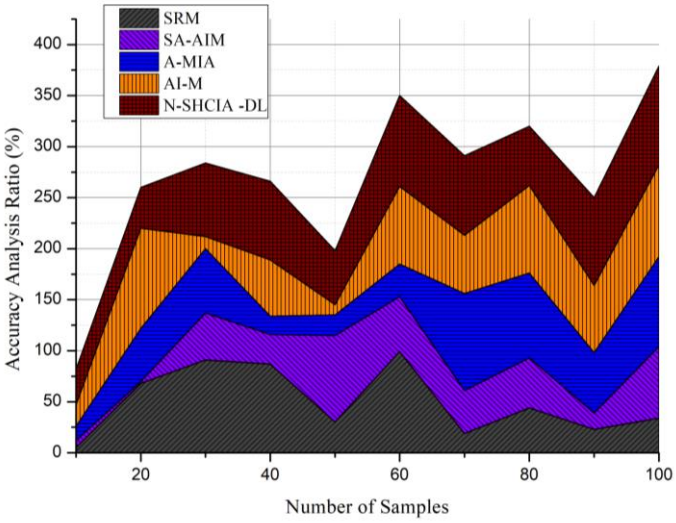

Figure 8: Accuracy analysis is compared with N-SHCIA-DL

Based on the expected accuracy, the results indicate that N-SHCIA is better than current methods, which have higher reliability and accuracy across different application domains. Its enhanced computational procedures and feature selection optimisation are the reasons for the improvements. Figure 8 compares N-SHCIA-DL with other deep learning models. With the introduction of deep learning, which enhances feature extraction and model generalisation, the results indicate that N-SHCIA-DL has better accuracy. Enhancing decision-making capacities while efficiently limiting computational errors is the aim of the proposed strategy. The findings indicate that N-SHCIA and N-SHCIA-DL perform better than other AI-based models, accurately predict future market trends, and leverage AI to enhance medical imaging. The findings indicate the importance of intelligent computing for future innovation and its transformative impact on precision-based tasks:

$$\forall_a q = Ia[v - nw''] + ur[w - ak'] * T[f - ke'] \quad (17)$$

The relationships $T[f-ke']$ between symbolic knowledge extraction ($\forall_a q$), neural-based feature adaptation ($Ia[v-nw'']$), and the regulation $ur[w-ak']$ of their interaction for optimal decision-making (T[f-ke^']) are shown in Equation (17). It makes AI-driven signal processing more efficient, versatile, and accurate.

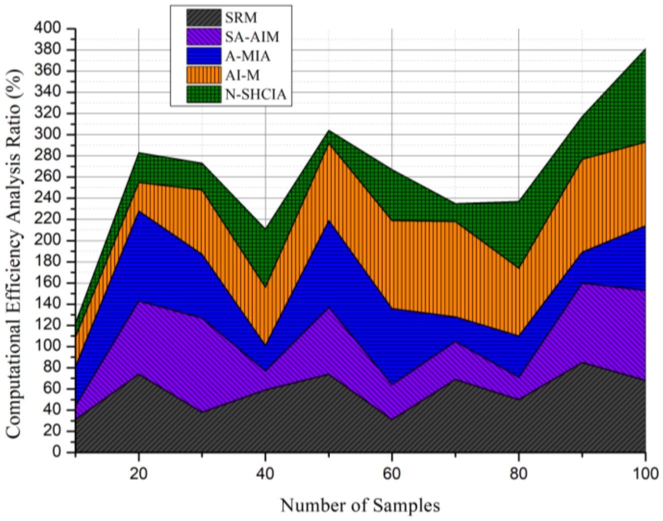

Figure 9: Computational efficiency is compared with N-SHCIA

The computational efficiency of various AI-based models is compared with that of the proposed N-SHCIA framework in Figure 9.

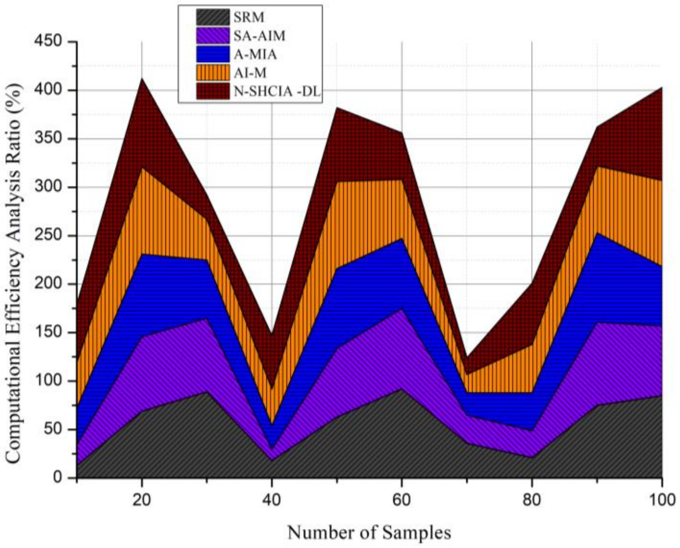

Figure 10: Computational efficiency is compared with N-SHCIA-DL

Figure 9 shows that N-SHCIA runs much faster while maintaining accuracy. The reasons for this evolution are an optimised algorithmic structure and effective resource management, which enable faster processing without sacrificing performance. Figure 10 also shows how N-SHCIA-DL compares with other deep learning models in terms of computational efficiency. According to the results, N-SHCIA-DL outperforms the other techniques because it applies deep learning-grade optimisation algorithms to minimise computational cost and improve model flexibility. The system architecture represents a compromise between cost and performance that is quite reasonable and, therefore, an optimal solution for real-time. In combination with the findings, the results support the idea that both N-SHCIA and N-SHCIA-DL are more effective models in terms of computational efficiency and can therefore be used in AI-based applications for financial forecasting, smart cities, and medical imaging. The findings confirm that the frameworks represent a significant leap in intelligent computing, as they can enhance performance without sacrificing resource utilisation:

$$p_c w = Ua[e - mk''] + Ytr[s - ani''] + Ut[w - ak'] \tag{18}$$

Equation (18) shows that for optimum decision-making, $p_c w$ manages symbolic information $Ut[w - ak']$, $Ua[e - mk'']$ models adaptation, neural modifications, and $Ytr[s - ani'']$ controls their interaction. This strategy improves the system's ability to manage high-dimensional data by increasing computational efficiency.

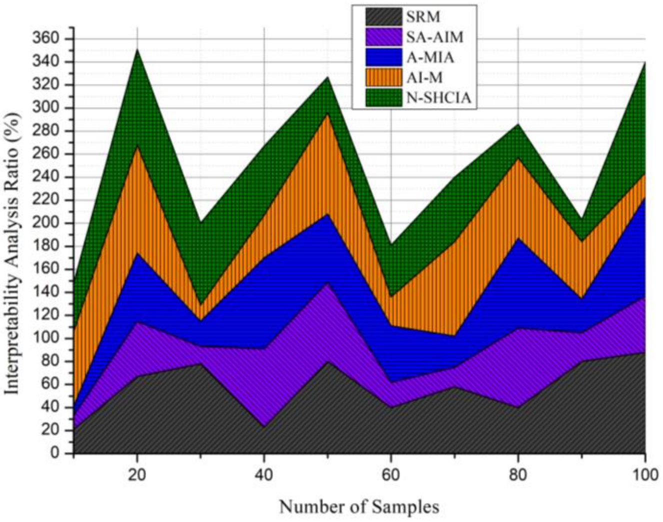

Figure 11: Interpretability is compared with N-SHCIA

As Figure 11 demonstrates, the proposed AI-based signal processing model is contrasted with N-SHCIA on interpretability, and this comparison is further extended to N-SHCIA-DL in Figure 12.

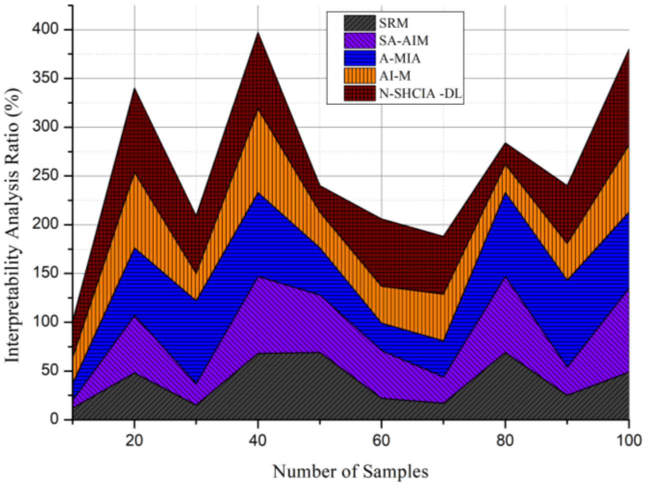

Figure 12: Interpretability is compared with N-SHCIA-DL

Through model simplification and provision of more accurate feature representations, the results indicate that the proposed method significantly enhances interpretability. By identifying signal changes and significant features, the proposed model surpasses N-SHCIA in decision-making explainability. Though N-SHCIA-DL performs better in data processing via deep learning, it is not particularly transparent, as deep models are inherently opaque. This limitation is overcome by the proposed model, which, by employing explainable AI techniques, is better suited for real-time use cases requiring trustworthy decisions. An AI-based framework offers several advantages for handling complex signal processing tasks, yielding better accuracy and greater flexibility. Making the model more efficient for scalable deployment in other computational informatics in maternal healthcare data tasks while maintaining its interpretability high may be an eventual objective:

$$P_c e = Iy[w - anu''] + Yr[w - and''] * Y[w - aki'] \tag{19}$$

The term $P_c e$ represents neural-driven learning in Equation (19), $Iy[w - anu'']$ represents symbolic reasoning modifications, and $Yr[w - and'']$ controls the interplay between $Y[w - aki']$ These three are for optimum inference. This method ensures improved scalability and interpretability in interpretability analysis.

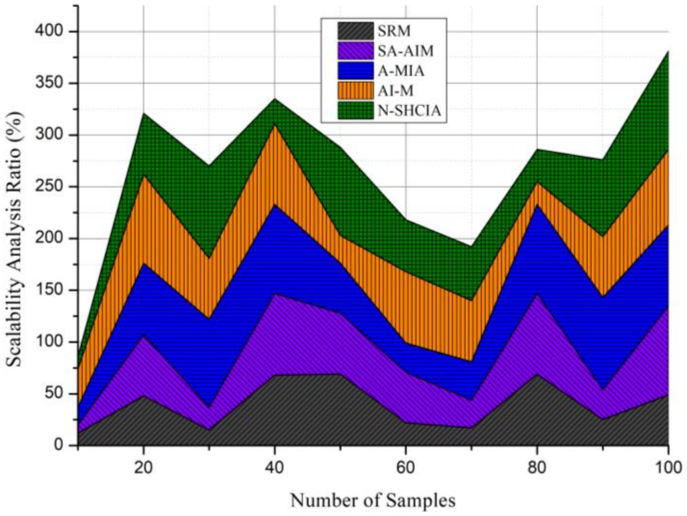

Figure 13: Scalability is compared with N-SHCIA

In Figure 13, the proposed AI-based signal processing model is compared with N-SHCIA on scalability, and in Figure 14, the comparison is extended to N-SHCIA-DL. The results indicate that the proposed method is highly scalable, i.e., it can handle increasingly growing data volumes with minimal or no performance loss.

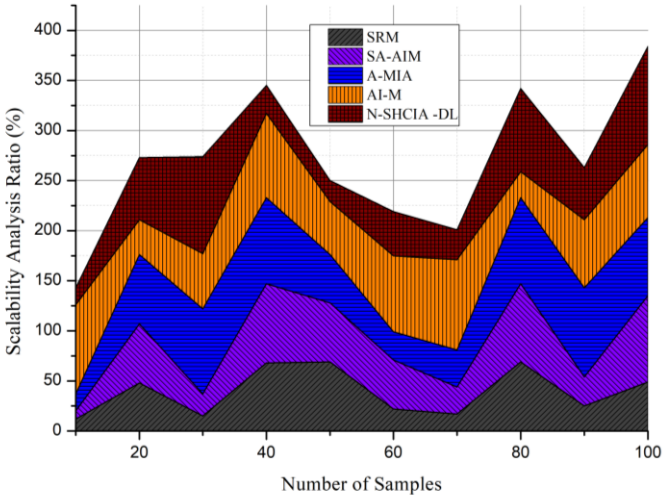

Figure 14: Scalability is compared with N-SHCIA-DL

The proposed method is well-suited to large-scale applications and offers consistent computational efficiency compared to N-SHCIA, which struggles with high-dimensional data. The proposed model improves resource utilisation and reduces processing overhead compared to N-SHCIA-DL. Deep learning poses significant computational challenges despite the increased automation in N-SHCIA-DL. All the same, the proposed framework is ideal for real-time and IoT applications because it optimises the model architecture to balance accuracy and efficiency. For computational informatics in maternal healthcare data and large-scale signal processing, future research can incorporate edge computing techniques to improve scalability, reduce latency, and enhance energy efficiency:

$$\forall_z w = Iu[a - bx'] + Yu[l - anw''] * R[w - an'] \tag{20}$$

To maximise decision-making $\forall_z w$, Equation (20) depicts the relationship $Iu[a - bx']$ between symbolic knowledge representation $Yu[l - anw'']$, deep learning-driven pattern identification $R[w - an']$, and the regulation of their integration. As a consequence, the system can process complex signals with increased scalability and analysis.

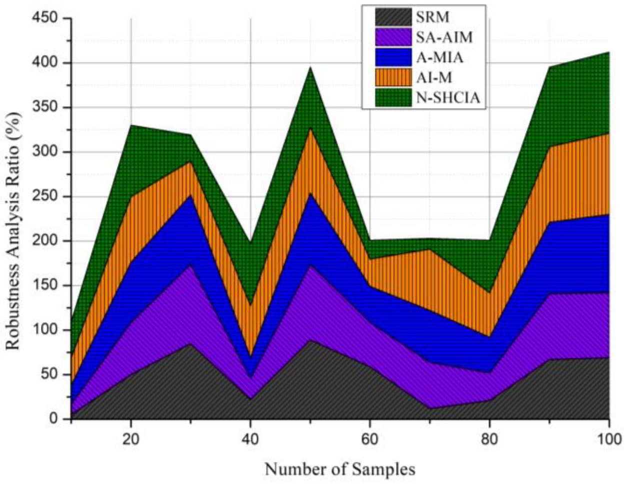

Figure 15: Robustness is compared with N-SHCIA

The proposed AI-based signal processing model is verified for its robustness against N-SHCIA in Figure 15 and N-SHCIA-DL in Figure 16. The results indicate that the proposed approach is more robust to noisy, varying signals. As opposed to N-SHCIA, which finds it challenging to cope with data quality variance and external interferences, the proposed model employs adaptive learning mechanisms to alleviate distortions in the signal and is always in touch with its performance in any environment. Compared to data inconsistency and adversarial noise, the proposed model is better than N-SHCIA-DL. Even though N-SHCIA-DL adopts deep learning in feature improvement, its reliability is thwarted by overfitting vulnerability and its fluctuation instability in unfamiliar contexts. On the other hand, the suggested design has a strong grasp of AI methods, making it less susceptible to inconsistencies in complex signal processing. Future research can further develop robustness, hybrid AI strategies, and adversarial training approaches to ensure that real-time systems are more dependable and resilient to faults:

$$P_c e = Ut[p]' - sn'[n - cbe''] + u[q - anu''] \quad (21)$$

Equation (21) illustrates the relationship $sn'[n - cbe'']$ between symbolic $u[q - anu'']$ refinements that are made by reasoning P c e and adaptive neural learning Ut p c -1] lead to better decisions. The strategy leads to improved pattern recognition and more coherent high-dimensional data processing, thereby enhancing robustness analysis.

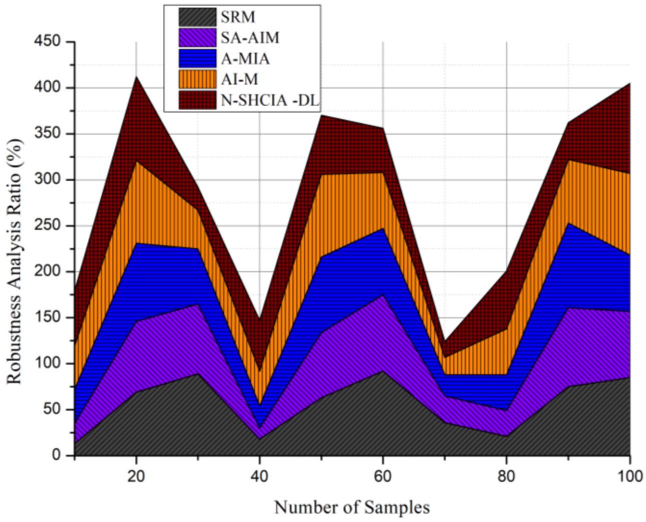

Figure 16: Robustness is compared with N-SHCIA-DL

Lastly, the robustness test demonstrates that the proposed N-SHCIA-DL structure can withstand noisy, dynamic signals, thereby improving on current methods. To make the identification of real-time signals and computational informatics in maternal healthcare more practical, future research can aim to maximise model performance by integrating edge computing, adversarial training, and hybrid AI-based model development.

5. Conclusion

This study has examined the groundbreaking impacts of AI in computational informatics within maternal healthcare data and signal processing, addressing issues such as noise reduction, high-dimensional data processing, real-time processing constraints, and model interpretability. Both classic statistical approaches and more recent deep learning models have been evaluated in our assessment of current procedures. The computational efficiency of signal processing, pattern detection, and adaptive filtering can all be significantly enhanced with AI-based methods. Better AI algorithms with a good balance between accuracy and computational cost may be the subject of future research, with a focus on enhancing AI for use in edge computing and the IoT. More scalable and secure real-time signal processing could be achieved through advances in quantum computing, hybrid AI models, and federated learning. More robust and smarter data processing solutions can be obtained by extending AI-based methods to new areas such as autonomous systems, biological signal analysis, and future wireless networks. This study has certain limitations, but it contributes in some ways. The application of enormous, labelled datasets for training AI systems remains a concern, and deep learning-based techniques can be further improved in terms of interpretability. More research is required to enhance the reliability of AI-driven systems, given their real-time processing constraints and vulnerability to security breaches. The effective use of AI in signal processing and computational informatics in maternal healthcare data will rely on algorithm optimisation, enhanced data-handling strategies, and the creation of secure AI frameworks to address these challenges.

Acknowledgement: The authors express their sincere gratitude to Srinivas University, SRM Institute of Science and Technology at Ramapuram, and SRM Institute of Science and Technology at Kattankulathur for their guidance and support.

Data Availability Statement: The datasets utilized in this study are available from the corresponding author upon justified request, subject to institutional policies and conditions to maintain transparency and reproducibility.

Funding Statement: The authors declare that this research was carried out without any financial assistance, sponsorship, or external funding.

Conflicts of Interest Statement: The authors affirm that there are no financial or personal conflicts of interest that could have impacted the research process or its conclusions.

Ethics and Consent Statement: This study was conducted in accordance with accepted ethical practices, and the authors consent to the sharing and accessibility of this work for academic, educational, and research purposes.

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