

# ADVANCEMENTS IN MEDICAL DIAGNOSIS THROUGH MACHINE LEARNING: A COMPARATIVE STUDY OF BRAIN TUMOUR, HEART DISEASE, AND BREAST CANCER DETECTION

Dr. Priya Mathur<sup>1</sup>, Ritu Saini<sup>2</sup>

<sup>1</sup>Professor- Department of Artificial Intelligence & Data Science Poornima Institute of Engineering & Technology  
Jaipur, Rajasthan- India

priya.mathur@poornima.org

<sup>2</sup>Student- Department of Artificial Intelligence & Data Science Poornima Institute of Engineering & Technology  
Jaipur, Rajasthan- India

sainiritu132@gmail.com

DOI: <https://www.doi.org/10.58257/IJPREMS37495>

## ABSTRACT

Machine learning has revolutionized the accuracy of diagnosis and treatment of such complex diseases as tumours in the brain, heart disease, and breast cancer. This is through its application in high algorithms that machine learning is processing large-sized datasets by finding patterns that may not be easily detected by human expertise on medical images, patient histories, and clinical data. This paper performs a comparative analysis of recent ML techniques-such as deep learning, feature selection, and ensemble methods-that have proven to improve the accuracy of these diagnostics significantly. Deep learning, in particular for image recognition tasks, has shown to improve the precision of the detection of abnormalities in brain scans or mammograms. One of the primary optimization techniques applied to optimize the prediction model for the heart disease application is feature selection. It focuses on the variables that have most influence on the application. Ensemble methods also improved performance because multiple models were used to minimize errors. Machine Learning (ML) Deep Learning (DL) Brain Tumour Detection Heart Disease Prediction Breast Cancer Detection Image Processing EEG Signal Processing Convolutional Neural Networks (CNN) Support Vector Machine (SVM) K-Nearest Neighbours (KNN) Decision Trees Random Forest Logistic Regression Hybrid Models Community Detection Feature Extraction Classification Structured Data Unstructured Data Medical Imaging Ensemble Techniques Nanoparticle Sensor Predictive Models Accuracy Multi-Stage Classification.

## 1. INTRODUCTION

This paper is raising an improvement in the ability of medical diagnosis through the use of machine learning. Early disease detection is a priority, especially for serious cases such as brain tumour, heart disease, and breast cancer, which are the most relevant health problems these days. The introduction outlines a great scope for ML-based applications to possibly improve the diagnostic accuracy and reduce the time taken to diagnose the disease, thereby ultimately resulting in better patient outcomes. The paper aims to dig into several applications of ML specific to such diseases by finding out how effective those are, the challenges encountered in their implementation, and opportunities for improvement in these diseases. Finally, the introduction states that this is done to take ML development forward to make better and more efficient diagnostic tools, thereby contributing to the field of healthcare and helping improve the quality of patient care.

### Brain Tumour Detection Using Machine Learning:

Brain tumour detection using machine learning is a highly effective use of advanced algorithms to analyse the data of medical imaging, for example, MRI scans for identifying and segregating tumours with great accuracy. Larger sets of images that are labelled with particular tumor types and characteristics can be used for training these models so that the distinguishing features learned are unique to each type of tumour or the set of characteristics within those tumours. Techniques in this regard are the CNNs, which in fact excel at dealing with visual data and at the detection of patterns subtle enough to escape the notice of the human eye. ML doesn't only speed up diagnosis but also reduces the human possibility of error through the automation of the process of detection. In addition to this, it can provide some kinds of quantitative assessments, which is entirely crucial in evaluating proper treatment planning concerning size and growth patterns of a tumour. Integrating machine learning into the detection of brain tumours does have promising prospects for the improvement of early diagnoses, better treatment, and saving of lives with the possibility of making medical intervention in time.

### Automated Brain Tumour Detection Using Image Processing Techniques:

Machine learning and image processing techniques have described the promising potential in automation of brain tumour detection. Using CNNs and image segmentation methods, it is now possible to develop automated detection systems

that can precisely diagnose tumours from MRI scans. This technique has been employed in the study conducted by Khan and Tiwari in the year 2020, and the system has reached an impressive degree of accuracy though the productivity depends upon the quality of the MRI images and the size of the dataset. Future work should include improvement in the resolution of the images and training with larger datasets.

#### **A Survey on Brain Tumour Prediction with Various Machine Learning Approaches:**

Singh and Patel (2021) attempted to survey all machine learning techniques such as neural networks, support vector machines, and random forests for the brain tumour prediction. Ensemble learning that is this combination of various above-mentioned techniques presents better predictions in terms of accuracy but requires much more computing resources than some single model. It still remains a significant challenge in real-time applications. Hybrid models might provide the best balance between the desired accuracy and the efficiency concludes the authors.

#### **Brain Tumour Prediction using Machine Learning Algorithm from EEG Signal:**

EEG signals would surely become a non-invasive prognosis method for the presence of brain tumours. Gupta and Jain (2021) prove the potential of random forests and SVMs in classifying EEG data as a new way forward towards the early detection of brain tumours. Even though the outcomes are promising, the study requires larger and more diverse datasets to be robust against patient populations.

#### **Hybrid Deep and Machine Learning Hybrid Approach to Brain Tumour Detection:**

Another is that work of Lee and Park (2022), CNN, in which they integrated it with the traditional ML models. The accuracy rate of detection decreases with only applying CNNs without combining them with other ML models; but, as the Hybrid goes, it breaks this standoff by its classifiers, especially SVM-like, and yields much better results. It is increased in computation, but its power of getting better diagnosis precision predicts the future ML improvements might be followed to optimize this hybrid model.

#### **Predicting Heart Disease with Machine Learning:**

Predicting heart disease via machine learning focuses on the analysis of patients' information to identify people likely to develop heart conditions. In doing so, using large numbers of machine learning algorithms, such as logistic regression, decision trees, and support vector machines, health care experts can process numerous data from demographic information, medical history, lifestyle, and test results in diagnostic tests for accurate prediction of heart disease using predictive models. These learn from historical datasets and understand the patterns and risk factors pertaining to the heart disease. Thus, predictions for new patients can be made for heart disease based on their unique profiles. For instance, age, hypertension, cholesterol level, smoking would all come to play in determining the probability of heart disease; such risks can be numerically comprehended by using machine learning models. A model with predictability capabilities not only enables early detection and intervention but also supports implementation of personalized treatment plans, allowing healthcare providers to get ahead of management when it comes to patient cardiovascular health. Ultimately, machine learning provides greater precision and speed in heart disease prediction and, by extension, contributes to enhanced patient results and reduced overall burden from heart-related conditions.

#### **Overview of Machine Learning Algorithms for Predictive Modelling of Heart Disease:**

Traditional ML methods such as logistic regression, decision tree, and random forests have been heavily used for heart disease prediction. Based on the comparison by Thomas and George (2022), it was indicated that the selection of features was the critical difference noticed between models. While ensemble-based techniques indeed showed the best performance, they require considerable computation and need further optimization to be used at a clinical scale.

#### **Heart Disease Prediction Using Machine Learning Algorithms:**

Ahmed and Sharma (2022) projected heart diseases with the help of support vector machines that surpassed other models. In the research report, feature engineering played an important role in selecting the patient data, such as blood pressure, cholesterol level, and age. Therefore, future work can try to use more developed feature selection methodologies to enhance their performance.

#### **Machine Learning and Deep Learning Models for Early Detection of Heart Disease:**

Kumar and Malhotra (2023) proved a comparison between traditional ML models and deep learning methods, where their research justified that neural networks happen to be superior to other models in each and every case based on large complex datasets. However, the use of deep learning needs a much higher computational power and high expertise involved to achieve the goal thereby limit its application directly into lesser technologically equipped medical settings.

#### **Machine Learning-Based Chronic Disease Heart Attack Prediction:**

For example, Banerjee and Jadhav implemented an ML predictive model that could predict heart attacks based on the real-time clinical data of patients suffering from chronic heart disease. The study therefore achieved high accuracy

through the application of decision trees and random forests in the prediction of heart attacks. Real time models have a potential in preventative healthcare but require larger datasets and improved integrations of real-time data to realize this full potential.

#### **Machine Learning in Breast Cancer Detection:**

Breast cancer detection through machine learning is an application of advanced computational methods for the analysis of medical images, either mammograms or ultrasounds or MRIs, to identify and classify potential tumours. The deep learning models, i.e., convolutional neural networks, are trained in large, annotated datasets with the images of growths that are benign or malignant so that these models can identify characteristics for benign or malignant growths. Machine learning accelerates the diagnosis process, incorporating improved detection accuracy and reduced risks of false positives and false negatives when relying on traditional approaches. Plus, it allows more patient data to be taken into consideration - genetic information, family history, and all the rest - to enhance the risk assessment. This cross-disciplinary approach will enable early diagnosis and timely intervention, which is important for improving survival rates and outcomes of treatment for breast cancer patients. Altogether, the integration of machine learning into breast cancer detection indicates an impressive step forward within the field of oncology, with health professionals being able to make more informed judgments to enhance patient care.

#### **Breast Cancer Detection Using Nanoparticle Sensors with Machine Learning Algorithms:**

Nanoparticle sensors with ML algorithms can non-invasively diagnose breast cancer. Saini and Roy (2023) have shown how k-NN and SVM can be used to classify sensor signals and yield very accurate results. Early detection of breast cancer might become significantly enhanced through the use of nanotechnology in diagnostics with the help of ML algorithms.

#### **Breast Cancer Prediction System Using Machine Learning Algorithms:**

Verma and Singh (2022) have established a breast cancer prediction system that utilized the random forest and SVM models. High accuracy was achieved in this system. It stressed that preprocessing and feature selection are highly vulnerable processes to performance. Improving such process shall increase the potential for making accurate predictions.

#### **Prediction of Breast Cancer Using Classical Machine Learning and Deep Learning Algorithms:**

Rodriguez and Fernandez (2023) compared classical ML algorithms such as decision trees with deep learning architectures of the CNNs. It has been seen that the accuracy obtained in image-based data was higher in CNNs, but in clinical data analysis, appropriate performance was obtained by classical algorithms. Authors have also devised a model of integrating these approaches for optimal breast cancer diagnostic tools.

#### **Detection of Breast Cancer by Application of Supervised Learning through AI and ML:**

Mishra and Kumar, 2022 sought to utilize supervised techniques- the neural networks in determining breast cancer based on images of mammograms. Although the models of neural networks bring out better accuracy, they have been trained extensively requiring large amounts of training and computation leading towards more substantial needs for efficient trainings.

#### **Comparative Insights:**

- **Accuracy vs. Complexity:** Deep learning models generally give higher accuracy, especially for non-structured data, like medical images such as MRI scans and sensor data, which can be visualized in brain tumours or in cases of breast cancer detection. These models come with a very high computational complexity that should not be desired when the computationally available resources are limited. Classical ML models are more straightforward in practice and computationally less extensive but compromise on accuracy to this extent.
- This model is determined by the nature of the source for the availability of the data. The deep learning models replace the classical models if the imaging data is at the gold standard for the diagnosis of the diseases, like brain tumours. Classical models also remain competitive within structured data environments such as predicting heart diseases.
- **Hybrid Approaches:** The hybrid models, which incorporate different techniques, have been very effective, particularly in increasing the accuracy in the results by including even more contextual or even innovative sources of data, such as application of community detection in heart disease prediction or nanoparticle sensors in breast cancer detection.

## **2. FUTURE SCOPE**

**Personalized Predictive Modelling and Precision Medicine:** The future of ML models for these diseases is to make use of high-dimensional patient data: genetic, molecular, and environmental factors that will be used to train personalized predictive models. Models will go further than only improving on personal risk predictions, helping target

screening approaches, and enable therapy plans to be devised on an individualized basis. More importantly, these models can help where treatment of a brain tumour strongly depends upon the nature of the tumour and patient profile.

**Real-Time Diagnosis and Monitoring Using Wearable and IoT Devices:** ML and wearable technology together can allow continuous monitoring of vital signs, physical activity, and biomarkers. There may also be wearable ECG monitors capable of the real-time detection of cardiac abnormalities due to heart diseases and are thus potentially ready to reveal a risk for a heart attack before even symptoms manifest. In the case of breast cancer, wearable devices can monitor hormone levels, changes in breast density, and other risk factors. In the case of brain tumours, data from EEG and neurological assessments can be integrated for better diagnostics.

**Hybrid and Multimodal Models for Thorough Analysis:** A hybrid deep-learning-based approach that can combine reinforcement learning with classical machine learning, in association with multimodal data- imaging, genetics, and patient history- can be designed to increase the precision of diagnosis. This can prove very helpful in brain tumour analysis as MRI, EEG, and genetic data added provide much more insight into the same.

**AI-Driven Treatment Optimization and Predictive Treatment Response:** ML models can predict the response of patients to a particular treatment. Treatment plans may be optimized and adjusted in accordance with the progress of patients. In case of breast cancer, AI would analyse tumor characteristics and genetic data to predict the efficacy of chemotherapy. Predictive models for heart diseases could serve as a basis for medication selection and interventions aimed at optimal patient outcome.

**Advanced Data Privacy and Federated Learning:** This includes developments in data privacy as well as federated learning which should empower institutions to co-train models, directly exposing the institutions to sensitive patient information through federated and private techniques. There may also be an amplification of training data scale as well as diversity, contributing to improved robustness among the differently demographics of patients and medical conditions, especially these three disease domains for better improvement from reduced model bias towards further accuracy.

**Early Detection by Preventive Genomics and Epigenetics:** The applications of ML in genomics can help to identify genetic predispositions early, particularly as genomic data are being made increasingly accessible. This could further calibrate risk assessments, such as that for the early detection and prevention and treatment of brain tumours, heart disease, and breast cancer based on a unique genetic and epigenetic signature of an individual.

**Artificial Intelligence for Radiologists and Clinicians:** Advanced ML algorithms may be used as assistants to radiologists in order to analyze and highlight anomalies with high precision in diagnostic imaging, which will enable faster and more accurate interpretations. This will enhance the workflows of diagnostics involving brain tumors using MRIs, heart conditions using echocardiograms, and breast tumors through mammograms, thus reducing the timelines for diagnosis and treatment.

#### **Advantages and Disadvantages:**

##### **Advantages:**

Other important benefits may include the potential for better accuracy of diagnosis and earlier detection. Compared to human experts, such large datasets containing imaging data, clinical histories, or genetic information allow ML algorithms to identify patterns not seen easily by humans. On the other hand, such data can be processed quite quickly by ML, therefore reducing the time spent on diagnostic procedures and thus lowering the waiting time of a patient for critical results. Advantages: More specific diagnostics and treatment approaches as a result of the knowledge obtained from patient-specific data, further improving treatments and even likely to reduce the costs for medical care.

#### **3. DISADVANTAGES**

The major drawback lies in the necessity for vastly huge and diversified datasets with the purpose of a proper training of such models, which could be an expensive as well as logistically arduous undertaking. Further, deep learning and complicated ML models require a great deal of computational power and may not be easily accessible in some resource-limited healthcare settings. Thirdly, use of ML models has implications regarding data privacy and security when sensitive medical information is utilized. Finally, the "black box" nature of some ML models, especially deep learning, makes it challenging for clinicians to interpret and trust the diagnostic recommendations, which may impact their adoption in clinical practice.

#### **4. CONCLUSION**

It is truly proved that machine learning has indeed improved the results of medical diagnostics regarding brain tumours, heart diseases, and breast cancer. Elucidated studies showed some level of success in the construction of ML models for disease detection but are still under pressure from constraints concerned with data and feature extraction as well as



computational resources. Hybrid models need more studies, which will enhance these possibilities by offering hybrid models that are deep learning techniques further optimized with the respective finer-tuned model and leverage real-time data to offer additional, person-specific diagnoses. As ML grew, so did its promise in the development of healthcare industry, which was offering more precise and efficient diagnostic models.

## 5. REFERENCES

- [1] Abdusalomov, A.B., Mukhiddinov, M., & Whangbo, T.K. (2023). Brain Tumor Detection Based on Deep Learning Approaches and Magnetic Resonance Imaging. *Cancers*, 15(4172).
- [2] Biswas, N., Mamun Ali, M., Abdur Rahaman, M., Islam, M., Rajib Mia, M., Azam, S., & Ahmed, K. (2021). Machine Learning-Based Model to Predict Heart Disease in Early Stage Employing Different Feature Selection Techniques. *Journal of Healthcare Informatics*.
- [3] Jia, W., Wang, Y., Chen, R., Ye, J., Li, D., Yin, F., & Shu, Q. (2024). Open-Source Pediatric Heart Sound Database with Congenital Heart Disease. *Journal of Medical Data*, 4(5), 102-120.
- [4] Kang, J., Ullah, Z., & Gwak, J. (2021). MRI-Based Brain Tumor Classification Using Ensemble of Deep Features and Machine Learning Classifiers. *Sensors*, 21(5), 2098.
- [5] Uddin, K.M.M., Biswas, N., Rikta, S.T., & Dey, S.K. (2023). Machine Learning-Based Diagnosis of Breast Cancer Utilizing Feature Optimization Techniques. *Journal of Cancer Research*, 12(3), 315-329.
- [6] Khan, H., & Tiwari, R. (2020). Automated Brain Tumor Detection Using Image Processing Techniques. *International Journal of Biomedical Imaging*, 8(4), 156-165.
- [7] Singh, P., & Patel, S. (2021). A Survey on Brain Tumor Prediction with Various Machine Learning Approaches. *Journal of Computational Science*, 9(2), 120-135.
- [8] Gupta, M., & Jain, A. (2021). Brain Tumor Prediction from EEG Signal Using Machine Learning Algorithms. *Journal of Medical Systems*, 45(9), 142.
- [9] Lee, S., & Park, D. (2022). Integrating Deep and Machine Learning Techniques for Brain Tumor Detection. *Journal of AI in Healthcare*, 6(3), 54-78.
- [10] Thomas, R., & George, D. (2022). A Review of Machine Learning Algorithms for Predicting Heart Disease. *Journal of Medical Informatics*, 11(1), 25-36.
- [11] K. Ahmed & P. Sharma, Heart Disease Prediction Using Machine Learning Algorithms. *Journal of Data Science*, 13(5), 98-112.
- [12] S. Kumar & P. Malhotra, Machine Learning and Deep Learning Models for Early Detection of Heart Disease. *Proceedings of the International Conference on Health Informatics*, 45, 192-208.
- [13] A. Banerjee & S. Jadhav, Machine Learning-Based Chronic Disease Heart Attack Prediction. *Journal of Predictive Analytics in Healthcare*, 14(2), 87-101.
- [14] Saini, R., & Roy, S. (2023). Breast Cancer Detection Using Nanoparticle Sensors with Machine Learning Algorithms. *Journal of Cancer Research and Diagnostics*, 10(4), 45-58.
- [15] Verma, N., & Singh, P. (2022). Breast Cancer Prediction System Utilizing Machine Learning Algorithms. *Journal of Medical Technology and Data Science*, 7(1), 34-49.
- [16] Rodriguez, M., & Fernandez, L. (2023). Predicting Breast Cancer Using Classical Machine Learning and Deep Learning Algorithms. *International Journal of Healthcare AI*, 9(3), 176-191.
- [17]
- [18]