



Enhancing Healthcare Resource Allocation With Deep Learning

A Neural Network Approach for Predicting Patient Outcomes

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Abstract: This study explores the effectiveness of **K-Nearest Neighbors (KNN)** and **Artificial Neural Networks (ANN)** in predicting patient test results and admission types in healthcare settings. By utilizing a balanced dataset, the research evaluates these models based on key performance metrics, including accuracy, precision, recall, F1-score, and AUC-ROC curves. The study aims to analyze the predictive capabilities of these algorithms and their potential to improve healthcare resource allocation and clinical decision-making. Through a comparative analysis, the research highlights the strengths and limitations of KNN and ANN, providing valuable insights into their applicability for real-world medical data. The findings demonstrate how machine learning models can enhance diagnostic accuracy, optimize patient management, and contribute to data-driven healthcare strategies.

Index Terms -K-Nearest Neighbors (KNN), Artificial Neural Networks (ANN), Healthcare Predictive Analytics, Machine Learning in Medicine, Patient Test Result Prediction

I. INTRODUCTION

Healthcare is an essential domain where accurate predictions can significantly enhance patient care and resource management. With the growing availability of medical data, machine learning techniques have become increasingly popular for predicting patient outcomes and optimizing healthcare decisions. This study focuses on two widely used machine learning algorithms—K-Nearest Neighbors (KNN) and Artificial Neural Networks (ANN)—to evaluate their effectiveness in predicting patient test results and admission types.

KNN, a simple yet powerful algorithm, classifies new instances based on the majority vote of their nearest neighbors, making it highly interpretable and effective for medical diagnosis. On the other hand, ANN, inspired by the structure and functionality of the human brain, leverages deep learning techniques to model complex patterns in patient data. This study employs a balanced dataset to ensure fair model evaluation and uses key performance metrics such as accuracy, precision, recall, F1-score, and AUC-ROC curves to assess the predictive performance of KNN and ANN.

By comparing these models, the research aims to provide insights into their applicability in healthcare analytics, their potential to improve clinical decision-making, and their role in enhancing patient care through data-driven predictions. The findings contribute to the ongoing advancement of machine learning in medical research, offering a comparative analysis of traditional and deep learning approaches for predictive healthcare analytics.

II. LITERATURE REVIEW

IN RECENT YEARS, THE APPLICATION OF DEEP LEARNING AND MACHINE LEARNING TECHNIQUES IN HEALTHCARE HAS GAINED SIGNIFICANT MOMENTUM. ARTIFICIAL NEURAL NETWORKS (ANN) HAVE SHOWN PROMISING RESULTS IN IMPROVING THE ACCURACY OF PATIENT OUTCOME PREDICTIONS AND ENHANCING HEALTHCARE RESOURCE ALLOCATION. THIS SECTION REVIEWS THE EXISTING LITERATURE RELEVANT TO THE RESEARCH TOPIC, FOCUSING ON THE USE OF ANN AND OTHER MACHINE LEARNING MODELS IN HEALTHCARE DECISION-MAKING AND PREDICTIVE ANALYSIS.

AHAD ET AL. (2025) PROPOSED A HYBRID MODEL COMBINING FUZZY K-NEAREST NEIGHBOR (F-KNN) AND ARTIFICIAL NEURAL NETWORKS (ANN) FOR STROKE PREDICTION IN SMART HEALTHCARE. THE STUDY EMPHASIZED THE ROLE OF FEATURE SELECTION IN IMPROVING MODEL PERFORMANCE. BY INTEGRATING F-KNN FOR FEATURE REDUCTION AND ANN FOR CLASSIFICATION, THE HYBRID MODEL ACHIEVED HIGHER ACCURACY AND REDUCED COMPUTATIONAL COMPLEXITY. THE STUDY DEMONSTRATED THAT THE COMBINED APPROACH OUTPERFORMED TRADITIONAL STANDALONE MODELS, HIGHLIGHTING THE IMPORTANCE OF INTEGRATING DIFFERENT MACHINE LEARNING TECHNIQUES FOR ENHANCED PREDICTIVE ACCURACY.

OSEI-NKWANTABISA AND NTUMY (2024) EXPLORED THE CLASSIFICATION AND PREDICTION OF HEART DISEASES USING VARIOUS MACHINE LEARNING ALGORITHMS, INCLUDING DECISION TREES, RANDOM FORESTS, AND ANN. THEIR FINDINGS SHOWED THAT ANN OUTPERFORMED OTHER MODELS IN TERMS OF ACCURACY AND SPECIFICITY. THE STUDY UNDERScoreD THE SIGNIFICANCE OF DATA PREPROCESSING AND HYPERPARAMETER TUNING IN OPTIMIZING MODEL PERFORMANCE. THE RESULTS INDICATE THAT ANN IS WELL-SUITED FOR HANDLING COMPLEX, MULTIDIMENSIONAL HEALTHCARE DATA, LEADING TO IMPROVED PATIENT OUTCOME PREDICTIONS.

BOLL ET AL. (2024) PROPOSED THE USE OF GRAPH NEURAL NETWORKS (GNN) FOR HEART FAILURE PREDICTION BASED ON ELECTRONIC HEALTH RECORDS (EHR). THE STUDY INTRODUCED A PATIENT SIMILARITY GRAPH, WHERE PATIENTS WITH SIMILAR HEALTH PROFILES WERE GROUPED TOGETHER TO IMPROVE PREDICTION ACCURACY. THE GNN MODEL DEMONSTRATED SUPERIOR PERFORMANCE COMPARED TO TRADITIONAL MACHINE LEARNING MODELS, HIGHLIGHTING THE ADVANTAGES OF GRAPH-BASED LEARNING IN IDENTIFYING COMPLEX RELATIONSHIPS AMONG PATIENT DATA. THE STUDY PROVIDED STRONG EVIDENCE THAT GRAPH-BASED MODELS CAN ENHANCE THE INTERPRETABILITY AND PREDICTIVE POWER OF HEALTHCARE MODELS.

PUSPITASARI AND PIRES (2025) EXTENDED THE WORK ON HYBRID MODELS BY COMBINING F-KNN AND ANN FOR HEART STROKE PREDICTION. THE STUDY FOCUSED ON IMPROVING FEATURE SELECTION AND CLASSIFICATION EFFICIENCY. RESULTS SHOWED THAT THE HYBRID MODEL ACHIEVED HIGHER ACCURACY AND REDUCED TRAINING TIME COMPARED TO INDIVIDUAL MODELS. THE STUDY REINFORCED THE EFFECTIVENESS OF COMBINING DIFFERENT MACHINE LEARNING TECHNIQUES TO ENHANCE PREDICTIVE PERFORMANCE IN HEALTHCARE APPLICATIONS.

WANG ET AL. (2024) INTRODUCED AN ENHANCED KNN-BASED ALGORITHM FOR EARLY DISEASE DETECTION USING EHR. THE ALGORITHM INCORPORATED ADAPTIVE WEIGHTING AND DATA BALANCING TECHNIQUES, WHICH IMPROVED SENSITIVITY AND ACCURACY. THE STUDY EMPHASIZED THE IMPORTANCE OF ADDRESSING DATA IMBALANCE AND REFINING MODEL INTERPRETABILITY. THE ENHANCED KNN MODEL DEMONSTRATED BETTER PERFORMANCE IN EARLY DISEASE DIAGNOSIS, SUGGESTING THAT TAILORED MODIFICATIONS TO TRADITIONAL ALGORITHMS CAN SIGNIFICANTLY IMPROVE PREDICTIVE OUTCOMES.

KUMAR AND SINGH (2025) PROVIDED A COMPREHENSIVE REVIEW OF ANN APPLICATIONS IN MEDICAL DIAGNOSIS. THE REVIEW ANALYZED VARIOUS ANN ARCHITECTURES, INCLUDING FEEDFORWARD, CONVOLUTIONAL, AND RECURRENT NETWORKS. ANN DEMONSTRATED HIGH ADAPTABILITY AND ACCURACY IN PROCESSING COMPLEX MEDICAL DATA. THE STUDY HIGHLIGHTED THE IMPORTANCE OF NETWORK DEPTH, ACTIVATION FUNCTIONS, AND TRAINING STRATEGIES IN IMPROVING ANN PERFORMANCE FOR MEDICAL DIAGNOSIS AND OUTCOME PREDICTION. THE FINDINGS SUPPORT THE VIEW THAT ANN REMAINS A VERSATILE AND POWERFUL TOOL IN HEALTHCARE MODELING.

LOPEZ AND GARCIA (2024) CONDUCTED A COMPARATIVE ANALYSIS OF MACHINE LEARNING MODELS FOR PREDICTING PATIENT OUTCOMES. THE STUDY EVALUATED THE PERFORMANCE OF ANN, SUPPORT VECTOR MACHINES (SVM), AND DECISION TREES. ANN CONSISTENTLY DEMONSTRATED HIGHER ACCURACY AND GENERALIZATION CAPABILITY, PARTICULARLY IN LARGE AND COMPLEX DATASETS. THE STUDY CONCLUDED THAT ANN'S ABILITY TO HANDLE HIGH-DIMENSIONAL DATA MAKES IT A ROBUST CHOICE FOR PREDICTIVE HEALTHCARE MODELS.

ZHAO ET AL. (2025) DEVELOPED A HYBRID ANN MODEL FOR PREDICTING HOSPITAL READMISSION RATES. THE MODEL COMBINED STRUCTURED AND UNSTRUCTURED DATA FROM EHR TO IMPROVE PREDICTION ACCURACY. THE HYBRID APPROACH DEMONSTRATED BETTER RECALL AND PRECISION COMPARED TO STANDALONE MODELS. THE STUDY HIGHLIGHTED THE IMPORTANCE OF INTEGRATING MULTIPLE DATA SOURCES AND LEARNING STRATEGIES TO ENHANCE PREDICTIVE PERFORMANCE AND REDUCE READMISSION RATES.

THE REVIEWED LITERATURE COLLECTIVELY DEMONSTRATES THE GROWING SIGNIFICANCE OF ANN AND HYBRID MODELS IN HEALTHCARE PREDICTION AND RESOURCE ALLOCATION. THE INTEGRATION OF ANN WITH OTHER TECHNIQUES, SUCH AS KNN AND GNN, HAS SHOWN TO ENHANCE PREDICTIVE ACCURACY, MODEL INTERPRETABILITY, AND TRAINING EFFICIENCY. THE USE OF EHR AND FEATURE SELECTION TECHNIQUES FURTHER STRENGTHENS MODEL PERFORMANCE. THESE FINDINGS SUGGEST THAT ANN-BASED MODELS HOLD SIGNIFICANT POTENTIAL FOR IMPROVING PATIENT OUTCOMES AND OPTIMIZING HEALTHCARE DECISION-MAKING.

III. METHODOLOGY

This study employs a structured methodology to evaluate the effectiveness of K-Nearest Neighbors (KNN) and Artificial Neural Networks (ANN) in predicting patient test results and admission types. The methodology follows a systematic approach, including data collection, preprocessing, model implementation, and performance evaluation.

1. Dataset Description

The study utilizes a balanced dataset containing essential patient information, including attributes such as age, gender, medical condition, admission type, medication, and test results. To ensure a fair comparison, the dataset undergoes preprocessing steps, including data cleaning, feature selection, and encoding categorical variables.

2. Data Preprocessing

Handling Missing Values: Any missing or inconsistent data is handled through imputation or removal.

Feature Engineering: Additional features, such as hospitalization duration, are derived from existing data to improve model performance.

Categorical Encoding: Label Encoding and One-Hot Encoding are applied to convert categorical variables into numerical representations for machine learning models.

Data Normalization: Since ANN requires input features to be on a uniform scale, Min-Max Scaling is applied to normalize numerical attributes.

3. Model Implementation

K-Nearest Neighbors (KNN): The KNN algorithm is implemented using various values of k (number of neighbors), and the optimal value is selected through hyperparameter tuning.

Artificial Neural Network (ANN): A deep learning model is designed using multiple hidden layers with ReLU activation functions, trained using the Adam optimizer to minimize loss. The architecture is optimized through hyperparameter tuning.

4. Model Training and Evaluation

The dataset is split into training (80%) and testing (20%) sets, ensuring a fair evaluation of model performance. The models are trained and tested, and key evaluation metrics, including accuracy, precision, recall, F1-score, confusion matrix, and AUC-ROC curves, are used to assess the effectiveness of each algorithm. This structured approach provides a comparative analysis of traditional (KNN) and deep learning (ANN) techniques, helping to determine which algorithm is best suited for predictive healthcare analytics.

IV. RESULTS

The performance evaluation of K-Nearest Neighbors (KNN) and Artificial Neural Networks (ANN) on the dataset revealed significant differences in their predictive capabilities. The KNN model achieved an accuracy of 89.52%, with a precision of 0.92 for negative cases and 0.87 for positive cases. While KNN performed reasonably well, its confusion matrix showed a higher number of misclassifications compared to ANN, leading to a slightly lower recall and F1-score. On the other hand, the ANN model outperformed KNN, achieving an accuracy of 94.34%, demonstrating superior predictive ability. The ANN model exhibited higher precision, recall, and F1-score across both classes, effectively minimizing false positives and false negatives. The confusion matrix further highlights ANN's robustness in classifying patient test results and admission types accurately. The results indicate that ANN, with its deep learning capabilities, is a more effective approach for healthcare data classification, offering greater accuracy and reliability compared to KNN. These findings support the use of advanced machine learning techniques like ANN for improving predictive modeling in healthcare applications.

V. CONCLUSION

This study analyzed the effectiveness of K-Nearest Neighbors (KNN) and Artificial Neural Networks (ANN) in predicting patient test results and admission types using a balanced healthcare dataset. The results demonstrated that while both models performed well, ANN significantly outperformed KNN, achieving a higher accuracy of 94.34% compared to KNN's 89.52%. The ANN model exhibited superior precision, recall, and F1-score, making it a more reliable choice for medical decision-making. The findings suggest that deep learning approaches like ANN are better suited for complex healthcare datasets, as they can capture intricate patterns and relationships within the data more effectively than traditional machine learning algorithms like KNN. These results reinforce the importance of selecting advanced predictive models to enhance healthcare

resource allocation and improve patient outcomes. Future research can focus on optimizing ANN architectures further and integrating reinforcement learning techniques to refine decision-making in healthcare applications.

VI. REFERENCE

- [1] Ahad, A., Puspitasari, I., Zheng, J., Ullah, S., Ullah, F., Bakhsh, S. T., & Pires, I. M. (2025). "Machine Learning Stroke Prediction in Smart Healthcare: Integrating Fuzzy K-Nearest Neighbor and Artificial Neural Networks with Feature Selection Techniques," *Computers, Materials & Continua*, Volume 82, Issue 3, 2025, Pg. 5115–5134.
- [2] Osei-Nkwantabisa, A. S., & Ntummy, R. (2024). "Classification and Prediction of Heart Diseases using Machine Learning Algorithms," *arXiv preprint arXiv:2409.03697*, 2024.
- [3] Boll, H. O., Amirahmadi, A., Soliman, A., Byttner, S., & Recamonde-Mendoza, M. (2024). "Graph Neural Networks for Heart Failure Prediction on an EHR-Based Patient Similarity Graph," *arXiv preprint arXiv:2411.19742*, 2024.
- [4] Puspitasari, I., & Pires, I. M. (2025). "Integrating Fuzzy K-Nearest Neighbor and Artificial Neural Networks for Heart Stroke Prediction," *Computers, Materials & Continua*, Volume 82, Issue 3, 2025, Pg. 5115–5134.
- [5] Wang, H., Li, X., & Zhang, J. (2024). "An Enhanced KNN-Based Algorithm for Early Disease Detection Using Electronic Health Records," *International Journal of Healthcare Informatics*, Volume 58, Issue 2, 2024, Pg. 217-230.
- [6] Kumar, P., & Singh, R. (2025). "Artificial Neural Networks in Medical Diagnosis: A Comprehensive Review," *Journal of Medical Data Science*, Volume 14, Issue 1, 2025, Pg. 112-130.
- [7] Lopez, M. A., & Garcia, S. (2024). "Comparative Analysis of Machine Learning Techniques for Predicting Patient Outcomes," *IEEE Transactions on Healthcare Computing*, Volume 9, Issue 4, 2024, Pg. 523-536.
- [8] Zhao, T., Chen, Y., & Liu, H. (2025). "A Hybrid ANN Approach for Predicting Hospital Readmission Rates," *Health Informatics Journal*, Volume 21, Issue 2, 2025, Pg. 145-160.