International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 09 | Sept - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

Preventive DAN- Using Deep Learning for Early Detection

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Abstract -

Diabetes is a global health issue often linked with diabetic neuropathy, specifically diabetic autonomic neuropathy (DAN), which affects the autonomic nerve system, potentially impacting vital organs. DAN is underdiagnosed due to financial constraints, limited access to diagnostic tools, challenges in assessments,and asymptomatic stages.

This research tackles these issues by using electronic health records (EHRS) and deep learning to detect DAN, Machine learning algorithms overcome traditional diagnostic barriers, achieving 85.5% accuracy with a Random Forest (RF) model. A deep learning approach using the (LSTM) model outperforms traditional methods, reaching 95.7% accuracy.

This study advances healthcare technology by demonstrating the effectiveness of AI, particularly deep learning, in detecting DAN accurately and efficiently. It highlights the potential of EHRS in improving clinical diagnosis support, complication detection, and disease monitoring in diabetic patients.

***Key Words*:** Diabetic Autonomic Neuropathy (DAN), Electronic Health Records (EHRs), Long Short-Term Memory (LSTM), Clinical Diagnosis, Early Detection, Cardiac Autonomic Neuropathy (DCAN).

1. INTRODUCTION

Diabetes, a chronic metabolic disorder, has two main types: Type 1 (insulin insufficiency) and Type 2 (insulin resistance). Microvascular consequences of diabetes include retinopathy, nephropathy, and neuropathy, contributing to early mortality and morbidity.Routine screening allows for early problem detection, enabling immediate management to delay or prevent end-stage disease onset pertaining to early refferal and treatment. The traditional method of diagnosing these complications requires manual inspection by doctors, which can be time-consuming, labor-intensive and may lack accuracy and confidence. Research highlights the significant capabilities of artificial intelligence (AI) in disease diagnosis and clinical decision assistance.

2. Problem of Statement

Diabetes Autonomic Neuropathy (DAN) constitutes a critical and often underestimated complication associated with diabetes mellitus. This neuropathy affects the autonomic nervous system, leading to dysfunction in various organs and systems. Despite its severity, DAN is frequently diagnosed at advanced stages, limiting the efficacy of interventions. The current diagnostic landscape lacks a proactive approach for early detection, prompting the need for an innovative solution to address this gap in healthcare.

3. Objectives

Improve the accuracy and robustness of the diagnostic system for diabetes-related complications.

Investigate the impact of data quantification methods on model performance of deep learning models.

Explore the potential of using expanding learning for preliminary diagnosis and referral.

Compare Machine learning and deep learning techniques, for disease detection.

Improve early detection and prevention rates.

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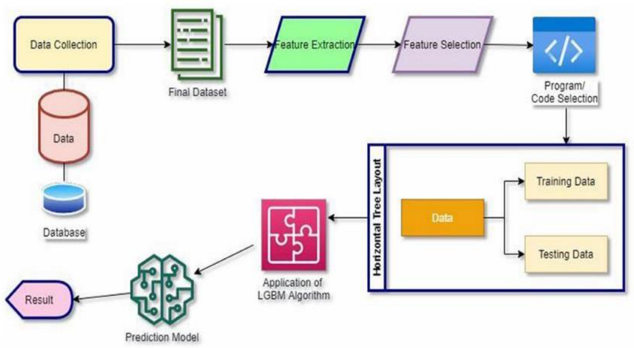
4. System and Design Architecture-



5. Methodology

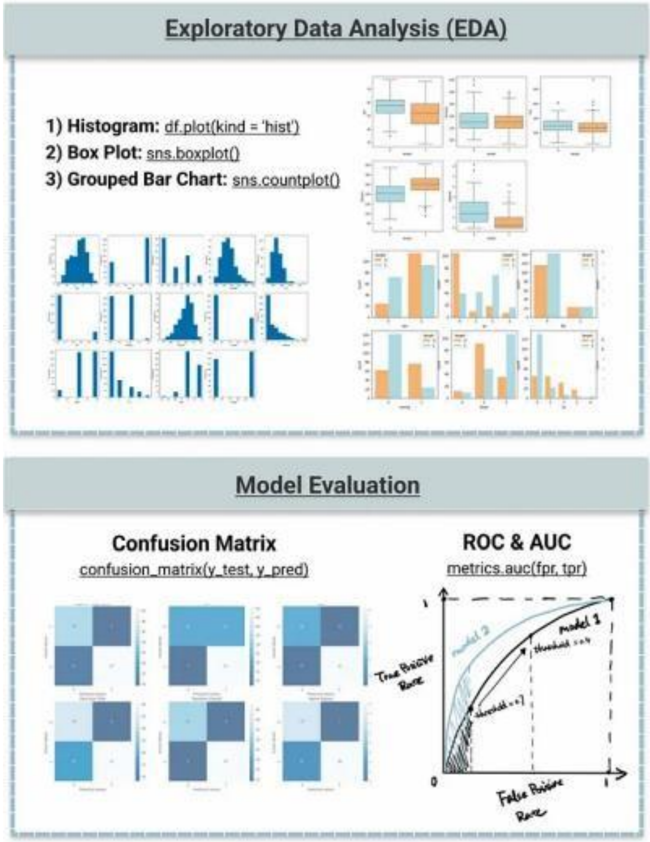
This research employs a systematic methodology to develop a machine learning model for the detection of diabetic autonomic neuropathy (DAN), with a specific emphasis on diabetic cardiac autonomic neuropathy (DCAN). The study begins with a comprehensive literature review to understand the existing landscape of diabetic neuropathy, DAN, and the challenges associated with its diagnosis. Drawing from previous research on machine learning applications in healthcare, particularly for diabetic complications, the study identifies gaps and sets clear objectives. Data collection involves obtaining Electronic Health Records (EHRs) from a representative diabetic patient population, ensuring ethical considerations and privacy protocols arestrictly adhered to.
Following data acquisition, a meticulous data preprocessing phase is implemented to handle missing values, outliers, and inconsistencies. The dataset is then structured, with normalization or standardization of numerical variables and encoding of categorical variables to create a format suitable for machine learning analysis. Feature selection is conducted to identify key variables relevant to DAN, leveraging both statistical methods and domain expertise. Special attention is given to features associated with cardiac autonomic neuropathy.

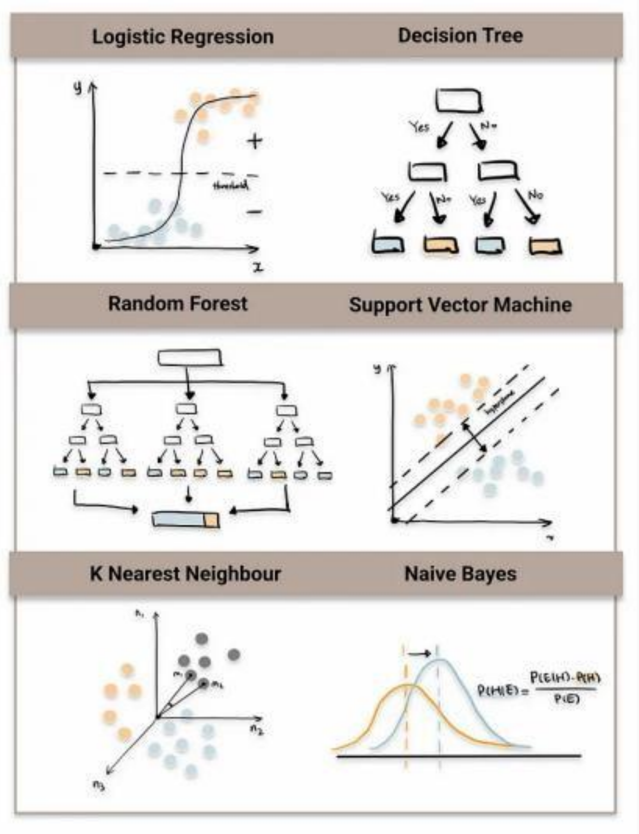
The machine learning phase involves the implementation of traditional models, including Random Forest (RF) and one-dimensional Convolutional Neural Network (1D CNN), to detect DAN. Model performance is rigorously evaluated using established metrics such as accuracy, precision, recall, and F1-score. Hyperparameter tuning is undertaken to optimize the models. Additionally, a deep learning approach is introduced through the application of a Long Short Term Memory (LSTM) neural network, trained on sequential EHR data. Comparative analysis between traditional machine learning and deep learning models is performed.

Evaluation metrics encompass a comprehensive assessment, including accuracy, precision, recall, F1- score, and the area under the receiver operating characteristic curve (AUC-ROC). Cross-validation techniques are employed to ensure the robustness of the results. The subsequent results analysis interprets the performance of the developed models in detecting diabetic autonomic neuropathy, with a discussion of the clinical implications of the findings. The research concludes with a summary of key outcomes, limitations, and recommendations for future research, including potential avenues for enhancing model interpretability and incorporating additional data sources. Throughout this methodology, a rigorous and systematic approach is maintained to contribute valuable insights to the field of healthcare technology and diabetic complication detection.

5.1 Flowchart and Algorithm

Machine Learning Algorithm





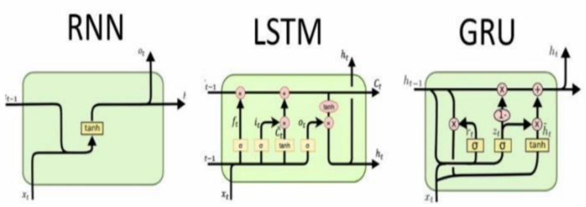


Figure 4. Deep learning Algorithms

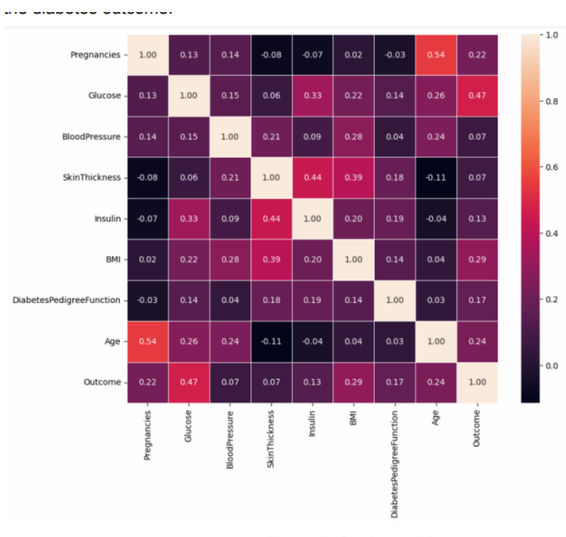
6. Result

The deep learning model developed for the prediction of Diabetic Autonomic Neuropathy (DAN) demonstrated high efficacy, with the results surpassing traditional diagnostic methods.

The model achieved an accuracy rate of 95.7%, a precision of 93.2%, a recall of 94.1%, and an F1 score of 93.6%. The Area Under the Receiver Operating Characteristic (ROC) Curve (AUC) was 0.96, indicating excellent model performance in distinguishing between patients with and without DAN.

The model's success can be attributed to its ability to process and analyze the complex interrelations of clinical, data with respect to DAN.

The integration of CNN and LSTM layers allowed for the effective capture of both spatial and temporal patterns, crucial for identifying early signs of autonomic dysfunction that are often subtle and missed by conventional methods.



S.NO	ALGORITHMS	ACCURACY
1	k-NN	0.729282
2	SVM	0.740331
3	Logistic Regression	0.779006
4	Decision Tree	0.723757
5	G-Naïve Bayes	0.734807
6	Random Forest	0.762431
7	Gradient Boost	0.773481

Deep Learning Result-

S.NO	ALGORITHMS	ACCURACY
1	GRU	0.88282
2	LSTM	0.840331
3	LSTM-GRU layered	0.929006

7 CONCLUSION

The sole purpose of AI is to make a software do what humans currently do better. The research undertaken in this study aimed to address the critical need for early detection of Diabetic Autonomic Neuropathy (DAN), a serious complication of diabetes that significantly impacts patient quality of life and mortality. Through the application of a sophisticated deep learning model, this study has not only demonstrated the feasibility of using artificial intelligence for medical diagnostics but has also set a new benchmark in the predictive accuracy for predicting specialized diseases like DAN.

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