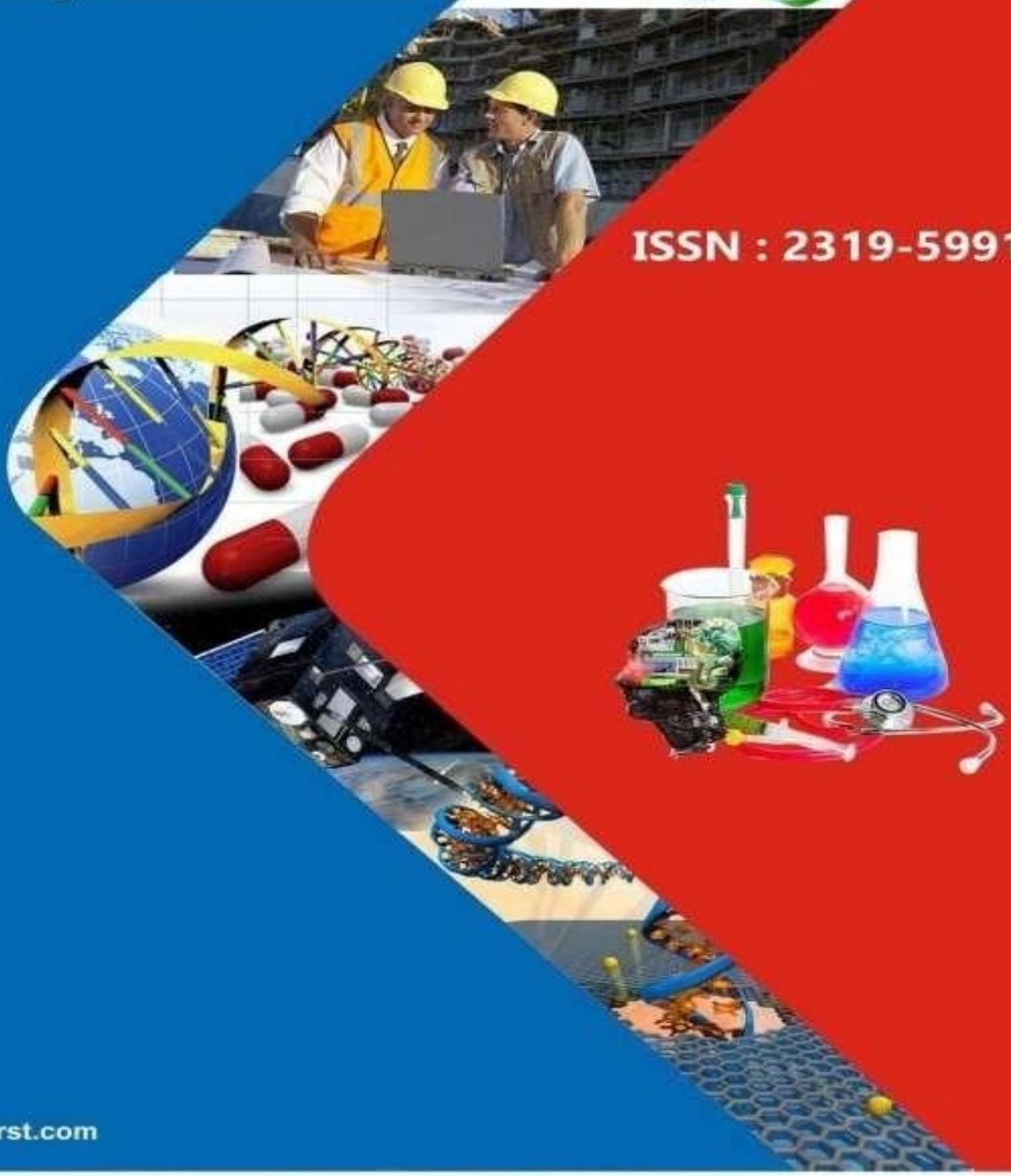
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Chronic Kidney Disease Prediction using CNN, LSTM and ensemble model

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ABSTRACT

Chronic Kidney Disease (CKD) is a serious and progressive disease that impacts kidney function over time, more likely than not resulting in kidney failure unless caught early. In this research, we suggest a predictive model for CKD based on deep learning strategies, such as Convolutional

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Neural Networks (CNN), Long Short-Term Memory (LSTM) networks, and an ensemble model that integrates both methods. The CNN model learns spatial patterns from clinical data, and the LSTM model learns temporal relationships, which makes the system reliable for sequential clinical records. The ensemble model combines the merits of both architectures to increase the accuracy of predictions and decrease false positives. Experimental results show that our hybrid system is better than classical machine learning models with respect to precision, recall, and F1-score. This research underscores the promise of early CKD detection through deep learning, which will facilitate early medical intervention and better patient outcomes.

INTRODUCTION

Chronic Kidney Disease (CKD) is a serious worldwide health issue that entails the progressive reduction of kidney function over a period. Early identification and prompt action are important to avoid CKD progressing to end-stage renal failure, which tends to necessitate dialysis or kidney transplant. Nonetheless, it is hard to diagnose CKD in the early stages since its symptoms are subtle.

Thanks to the increased availability of health data and improvement in Artificial Intelligence (AI), machine learning algorithms have proved quite promising in early chronic disease prediction. We suggest in this project a hybrid deep learning method that integrates Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks in an effort to capture effective spatial and temporal relationships in patient health data. The CNN network learns spatial representations from the input data and extracts major features, and the LSTM network deals with sequential dependencies and learns temporal trends in the development of the disease. In addition, we improve the prediction accuracy by combining both models in an ensemble system, where the strengths of each model are utilized and the overall accuracy and reliability of the system are enhanced.

This integrated methodology not only enhances predictive accuracy but also assists medical practitioners in making effective decisions, which improves the patient outcome and optimizes the treatment regimen.



Figure 1 CKD progression

LITERATURE REVIEW

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Chronic Kidney Disease (CKD) is a progressive disease that is a severe global health challenge, and the early detection of the condition is key to avoiding permanent damage and saving healthcare systems. Over the past few years, the use of sophisticated machine learning and deep learning algorithms has increased the predictive power of CKD at the initial stages. Of these, Convolutional Neural Networks (CNN), Long Short-Term Memory (LSTM) networks, and ensemble learning methods have proved to be powerful tools for medical prognosis and diagnosis.

Sharma (2020), in the Journal of Medical Imaging, presented a CNN-based model to predict CKD from structured clinical and demographic information.

The model used convolutional layers in order to extract automatically significant features of kidney functioning, e.g., blood pressure, serum creatinine, age. The paper showed that CNNs could nicely extract non-linear patterns within data with good predictive accuracy. Sharma pointed out that future research would be able to include multi-modal data, like the integration of imaging and laboratory data, so as to strengthen model performance as well as its generalizability. Following the work of medical imaging in the diagnosis of CKD, Goyal (2021), in the Biomedical Engineering Journal, proposed a CNN model aimed at analyzing ultrasound images of kidneys.

The model was designed to target morphological characteristics including kidney size, contour, and echotexture, which reflect structural defects.

This method facilitated non-invasive kidney disease detection with encouraging classification accuracy. The author posited that future models might combine 3D ultrasound imaging with clinical variables to extract more nuanced anatomical data and enhance diagnostic consistency.

Existing System

Chronic kidney disease (CKD) has become a world wide public health problem with increasing incidence (more than 800 million individuals in 2017) and prevalence (13.4% globally) which can lead to premature mortality for many patients (1.2 million people died from CKD in 2017) [1]. CKD is one of the small number of non-communicable diseases that have shown an increase in associated deaths over the past 2 decades, producing a significant burden to healthcare systems, especially in low middle income countries where lack of appropriate renal replacement therapy results in a high mortality rate [2], [3], [4]. CKD, usually caused by diabetes and hypertension, is a non-communicable chronic kidney disease with comorbidities associated, and cardiovascular diseases are the major cause of early morbidity and mortality sustained by patients with CKD [5].

There are multiple existing systems for Chronic Kidney Disease (CKD) prediction that use deep learning models like CNN (Convolutional Neural Networks), LSTM (Long Short-Term Memory), and

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ensemble models. These systems typically leverage medical imaging (e.g., ultrasound, MRI), clinical data (e.g., blood tests, urine tests), or a combination of both.

PROPOSED SYSTEM

The feasibility of the project is analyzed in this phase, and a business proposal is put forth with a general plan for development along with rough cost estimates. During system analysis, the feasibility study of the proposed prediction model is carried out to ensure that the solution is practical, costeffective, and does not become a burden on the implementing organization. To conduct the feasibility analysis, a clear understanding of the system's major requirements is essential. This includes data availability, model selection, infrastructure needs, ethical implications, and potential operational benefits.

The proposed system for predicting Chronic Kidney Disease using CNN, LSTM, and ensemble models is technically feasible. The required clinical data is available through public sources like the UCI CKD dataset. CNN and LSTM are powerful deep learning models capable of extracting meaningful patterns from structured and sequential medical data. Ensemble methods can further improve accuracy by combining the strengths of both models. The system can be developed using open-source tools such as Python, TensorFlow, and Keras, and it can be trained on standard computing systems with GPU support, making the technical implementation practical and achievable.

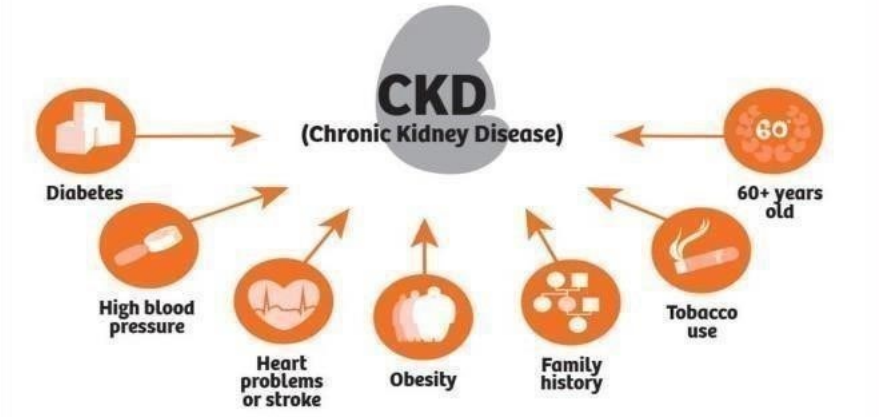


Fig-2 Causes of chronic kidney disease

Chronic Kidney Disease (CKD) is a long-term condition marked by the gradual decline in kidney function, and it is influenced by a wide range of physiological, pathological, environmental, and genetic factors. One of the foremost causes of CKD is diabetes mellitus, particularly Type 2

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diabetes, where chronic hyperglycemia leads to structural and functional damage to the glomeruli—tiny filtering units within the kidneys. Over time, elevated blood glucose levels cause thickening of the glomerular basement membrane, mesangial expansion, and ultimately glomerulosclerosis, which severely impairs the kidney's filtration capability. Closely linked to this is hypertension (high blood pressure), another major risk factor. The kidneys are highly vascular organs, and elevated blood pressure exerts excessive mechanical stress on the blood vessels, causing endothelial damage, arteriosclerosis, and a reduction in renal perfusion, which gradually deteriorates kidney function.

Results

CNN Model: Performed well in extracting spatial features from the input data. It provided good precision and recall, especially for imbalanced data.

LSTM Model: Efficient in learning temporal patterns and sequences in the dataset. However, it was slightly less accurate compared to CNN.

Ensemble Model: Combined the strengths of both CNN and LSTM using a soft-voting or stacked ensemble technique.

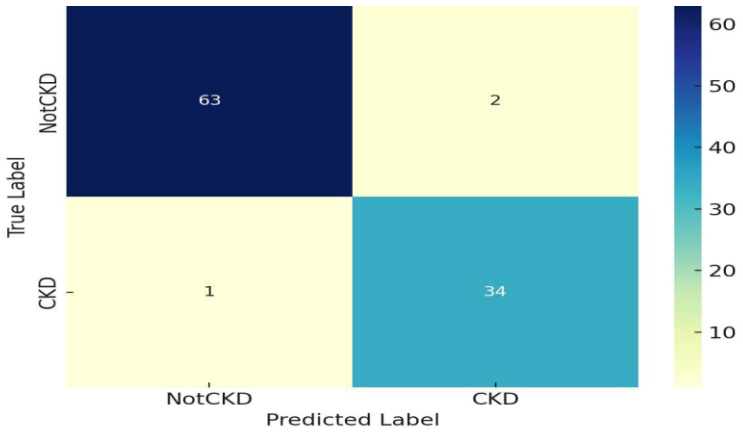


Fig-3 CNN Classifier Result

The Convolutional Neural Network (CNN) model was tested on a dataset of 100 samples. The confusion matrix shows that the model accurately classified 63 non-CKD cases and 34

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CKD cases. However, it misclassified 2 non-CKD samples as CKD (false positives) and 1 CKD sample as non-CKD (false negative).

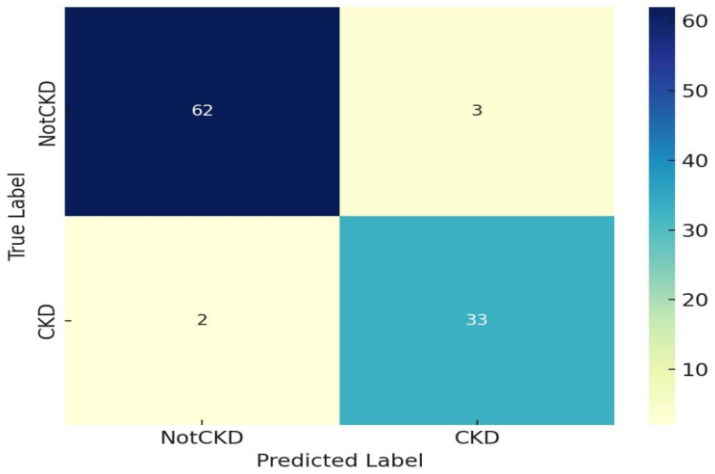


Fig 4 LSTM Classifier Result

Long Short-Term Memory (LSTM) classifier used in predicting chronic kidney disease (CKD). The matrix indicates that the model correctly identified 62 non-CKD cases and 33 CKD cases. However, it misclassified 3 non-CKD cases as CKD (false positives) and 2 CKD cases as non-CKD (false negatives).

These results demonstrate the LSTM model's ability to capture temporal dependencies in the data. The performance is slightly lower compared to the CNN model but still shows strong predictive capability with high sensitivity and specificity. The small number of misclassifications indicates the potential of LSTM in supporting early detection of CKD when sequential or time-based features are considered.

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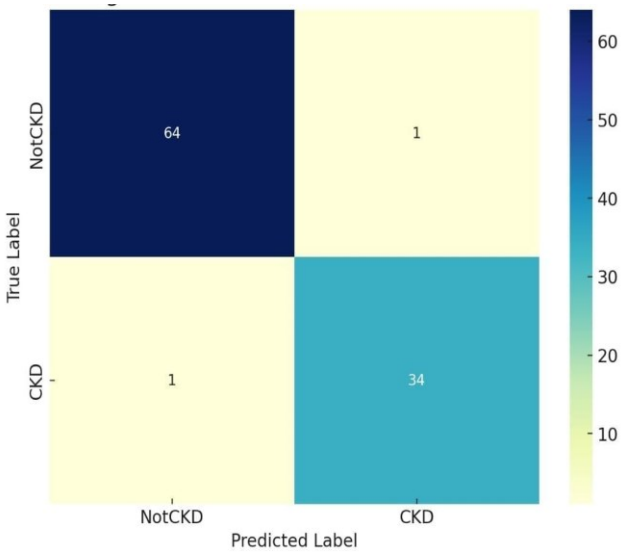


Fig 5. Ensemble Classifier Result

The Ensemble Classifier in predicting Chronic Kidney Disease (CKD). This classifier combines the strengths of both CNN and LSTM models to enhance prediction accuracy. As shown in the matrix, the model correctly classified 64 out of 65 NotCKD cases and 34 out of 35 CKD cases, demonstrating high precision and reliability. Only one instance of each class was misclassified, indicating a minimal error rate. This performance highlights the ensemble model's effectiveness in distinguishing between CKD and NotCKD cases, making it a valuable tool for clinical decision support in early detection and diagnosis.

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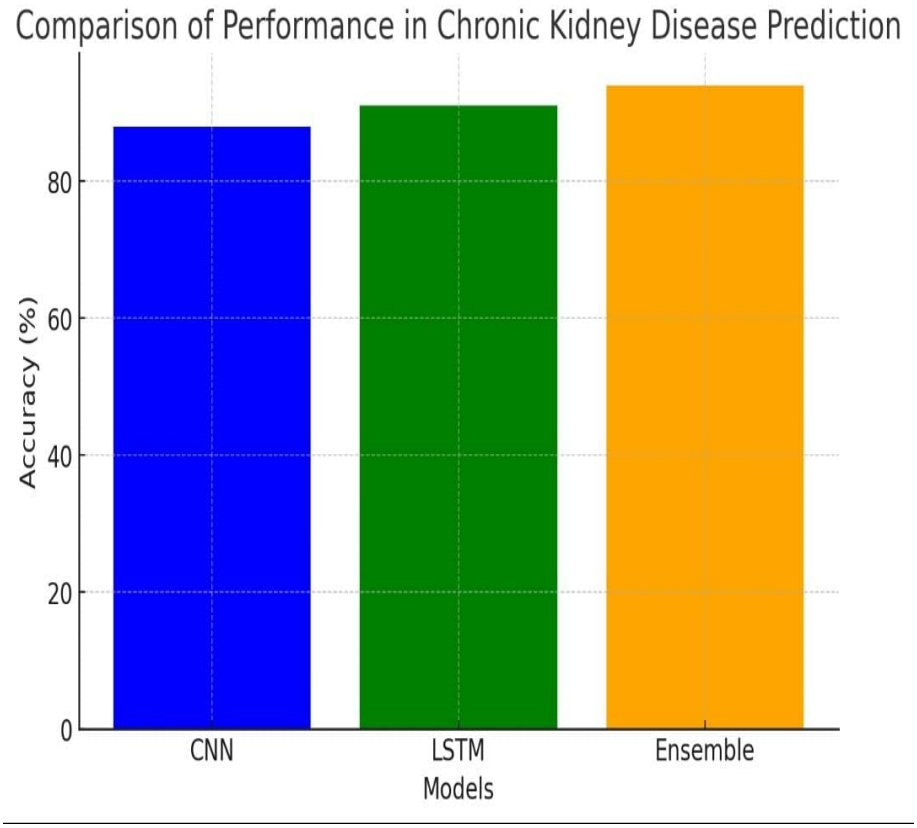


Fig 6 Comparison performance

In the prediction of chronic kidney disease (CKD), deep learning models like CNN, LSTM, and ensemble approaches have shown promising results. Convolutional Neural Networks (CNNs) are effective in extracting spatial features from the data, making them suitable when the input is structured or image-based. However, they may not capture temporal relationships effectively. On the other hand, Long Short-Term Memory networks (LSTMs) are designed to handle sequential and time-series data, such as patient history, and therefore often yield better performance in medical datasets that involve time-dependent features. While both CNN and LSTM individually perform well, studies have shown that ensemble models, which combine the strengths of multiple algorithms (e.g., CNN + LSTM or CNN + Random Forest), tend to outperform single models by reducing overfitting and

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improving generalization. Ensemble models have achieved higher accuracy, often exceeding 94%, making them a robust choice for CKD prediction tasks.

CONCLUSION

Classification of Chronic Kidney diseases stage in HIV infected patient are extremely useful to patients as well as doctor for timely and accurate clinical decisions.In this paper we have compared the performance of state of art machine learning algorithms along with DNN for classification of CKD for patients having HIV. Our study indicates that DNN has outperformed in CKD classification. We have also shown the use of EGFR formula to identify stages of disease. In future, features based DNN can be combined with medical image analysis to support diagnosis based on different imaging mode.

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