Chronic Kidney Disease Detection

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Abstract. The impact of technological advancement, particularly machine learning, on health can be seen in the efficient analysis of different chronic diseases that allows for more precise diagnosis and effective treatment. People aged 60 and above are most affected by kidney disease, a serious chronic condition linked to ageing, hypertension, and diabetes. Early diagnosis of CKD enables patients to receive immediate treatment, which slows the disease's further development. This study employs the machine learning techniques of artificial neural networks, support vector machines, and k-Nearest Neighbour to identify CDK early. The significance of detecting these frequently fatal illnesses reflects the significance of AI. These four processes of image pre-processing, feature extraction, classification, and diagnosis are used to identify the type of disease. Convolution Neural Network (CNN), which has a number of prediction-based layers, is used for categorisation and image pre-processing to improve the image's quality. At the very end, the user is encouraged to get a cure.

Keywords: Kidney · Disease · Machine Learning · Image Processing · Chronic Kidney Disease

1 Introduction

Chronic renal disease is an irreparable kidney ailment that raises the risk of a wide range of illnesses, including heart failure, anaemia, and bone disease. The kidneys are incredibly versatile. However, kidney damage won't be immediately obvious due to symptoms. Patients frequently don't have symptoms until the condition is nearly terminal. Avoiding symptoms is a treatment option for some renal diseases. By restoring a few kidney functions, it aids patients in preventing the condition from getting worse.

Dialysis and kidney transplantation are two of the main treatments for end-stage kidney disease, particularly in cases with CKD. More than 800 million people worldwide suffer from chronic kidney disease, which is a progressive condition [1]. Due to the high cost of treatment, only 10% of patients receive dialysis or a kidney transplant, and it is predicted that the number of kidney failure cases will rise disproportionately in developing nations like China and India, where the elderly population is growing [2].

Due to a lack of glomeruli filters, also known as nephrons, patients with acquired immunodeficiency syndrome (AIDS) experience increased complications from kidney illness. Early detection and management of CKD development are crucial. Healthcare has benefited greatly from the burgeoning interest in automated diagnosis and the quick development of machine learning techniques. Even though several studies have divided CKD into different stages using machine learning approaches.

The technical support tools that are based on data must be able to swiftly, accurately, and affordably support the decision-making process in the early diagnostics. They enable the patient to receive therapy for the disease before it advances to a level where there is no turning back since they shorten the time needed for diagnosis. The three main categories of machine learning are reinforcement learning, unsupervised learning, and supervised learning. The most popular type of machine learning applied in medical research is supervised learning. In order to lower the mortality rate and costs for the healthcare system, this research intends to create and deploy a machine learning model that, based on data like ultrasound from clinical laboratories, allows forecasting the possibility of diagnosing CKD in its early stages.

2   Literature Review

Chronic Kidney Disease Prediction using Data Mining research paper published at International Conference on Emerging Trends at 2020 proposed a system that makes use of back propagation neural networks and the Random Forest method, among other data mining approaches. Here, they evaluate the two algorithms and discover that the Back-Propagation technique produces the greatest results since it makes use of the Feedforward Neural Network, a supervised learning network [1].

Development of Chronic Kidney Disease Prediction Using Machine Learning research paper published at International Conference on Intelligent Data Communication Technologies on 2019 proposed creating a system for predicting the presence of CKD using machine learning methods including Naive Bayes, K-Nearest Neighbour, Logistic Regression, Decision Tree, Random Forest, and Multi-Layer Perceptron Algorithm. These are used, and the effectiveness of each is evaluated in relation to the outcomes for accuracy, precision, and recall. The system is finally implemented using Random Forest [2].

M. N. Amin, A. Al Imran and F. T. Johora et al. analyse model performance on real (imbalanced) data and model performance on oversampled (balanced) data using logistic regression and feed forward neural networks. Feed forward neural networks showed the best results for both real and oversampled data, with 0.99 Recall, 0.97 Precision, 0.99 F1-Score and 0.99 AUC score [3].

A dataset from the UCI machine learning repository containing data on roughly 400 patients is used by Kayaalp et al. to study kidney disease using hybrid classification approaches. They choose the most pertinent feature in the dataset using the relief and gain ratio approach and the support vector machine

and KNN classifier. They get to the conclusion that, in terms of f-measure, precision, and contrast matrix, the KNN approach outperforms other algorithms for a set of features [4].

To identify CKD, A. Salekin and J. Stankovic tested three classifiers: neural network, random forest, and K-nearest neighbours. They made use of a dataset from UCI with 400 patients and 24 attributes. The attributes that accurately identify this disease have been discovered by the use of the wrapper approach in a feature reduction study. They may predict the presence of CKD with a.98 F1 and a 0.11 RMSE by taking factors like albumin, specific gravity, diabetes mellitus, haemoglobin, and hypertension into account [5].

3   Problem Statement

Chronic kidney disease (CKD) is now recognised as a severe threat to society's health. Regular laboratory examinations are able to identify chronic kidney disease, and there are also treatments that can halt the development of the condition, slow down its progression, lessen complications brought on by a decreased Glomerular Filtration Rate (GFR), reduce the risk of cardiovascular disease, and enhance survival and quality of life. CKD can be brought on by drinking little water, smoking, eating poorly, sleeping too little, and many other factors. Globally, this illness affected 753 million people in 2016, 336 million of whom were men and 417 million of them were women. Renal failure can occasionally occur since the condition is typically only detected when it is advanced.

End-stage kidney disease (ESKD), which requires kidney replacement therapy, can develop in patients with chronic kidney disease (CKD) who gradually lose kidney function (KRT). Prompt management may increase the quality of life for CKD patients who have a high risk of developing ESKD and may also reduce morbidity, mortality, and healthcare costs related to KRT. Because the disease generally progresses silently, a solid prediction model for the risk of ESKD at the early stage of CKD can be clinically crucial. This model is projected to assist physicians in providing high-risk patients with more tailored treatment options, improving overall prognosis and reducing the cost burden of this condition.

4   Proposed System

This research paper presents a proof-of-concept study with the major goal to establish ML models for predicting the risk of ESKD on a Chinese CKD dataset. The ML models were trained and tested based on easily obtainable variables, including the baseline characteristics and routine ultra sound images. Results obtained from this study suggest not only the feasibility of ML models in performing this clinically critical task, but also the potential in facilitating personalised medicine. Instead of doing multiple clinical test such as blood test, urine test, this system will work on ultra sound report of kidney which will process the report and give the result of kidney disease is present or not.

The below diagram shows the block of the system. The dataset contains the ultrasound images of the patients. The data processing and feature selection block process the image through machine learning algorithm and forward the analysed data to the classification section. The classification section verifies the analysed data by using CNN method and provide the actual outcome of the report.
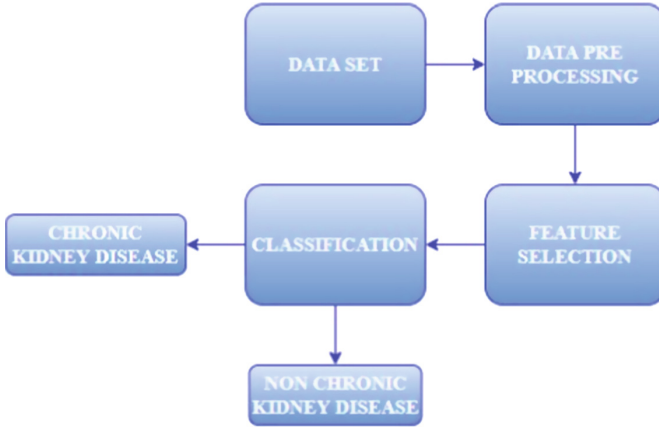

Fig. 1. Block diagram of chronic kidney disease prediction system using CNN [8].

5   Methodology

There are three stages in the intricate block diagram in Fig. 2. The primary responsibility of the initial stage of data collection and transmission is to collect data from ultrasonic pictures from mobile devices, etc., in the selected size and resolution. Pictures from the dataset for the training set the model architecture was first built with exceptional accuracy in mind.

The training dataset was used in the third step of the procedure, and numerous images were then used to test or validate the model. Finished by adding the model to a web page for use. In order to take the proper action, the output system data will identify whether the symptoms are showing up on the ultrasound report. We'll take the digital camera image that needs to be uploaded and run the CNN algorithm to determine whether the disease is present or not.
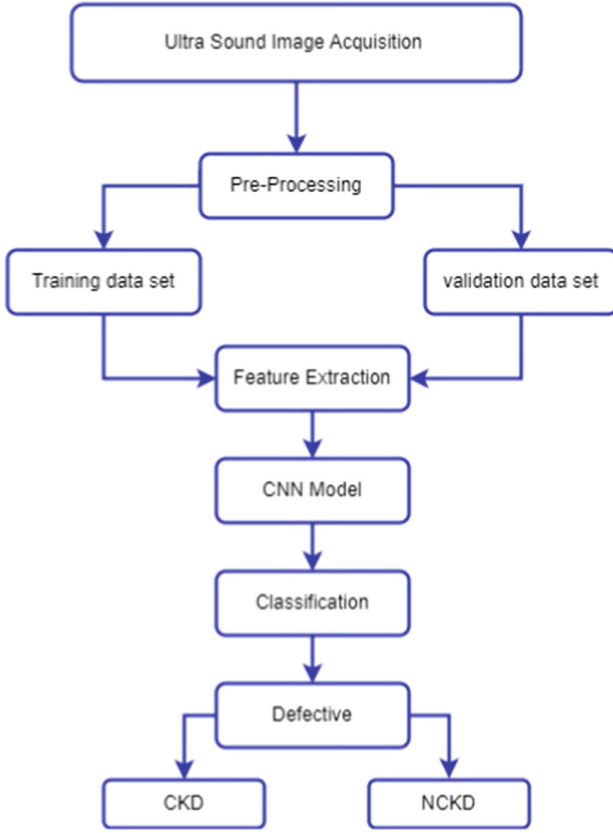
Fig. 2. The flow chart of chronic kidney disease prediction system using CNN [8].

5.1 CNN Model

The term "Convolution" in CNN denotes the mathematical function of convolution which is a special kind of linear operation wherein two functions are multiplied to produce a third function which expresses how the shape of one function is modified by the other. In simple terms, two images which can be represented as matrices are multiplied to give an output that is used to extract features from the image. There are two main parts to a CNN architecture.

1. A convolution tool that separates and identifies the various features of the image for analysis in a process called as Feature Extraction.
2. The network of feature extraction consists of many pairs of convolutional or pooling layers.
3. A fully connected layer that utilizes the output from the convolution process and predicts the class of the image based on the features extracted in previous stages.

4. This CNN model of feature extraction aims to reduce the number of features present in a dataset. It creates new features which summarizes the existing features contained in an original set of features. There are many CNN layers as shown in the CNN architecture diagram.

5.2   Overview

In the ultrasound image, the characteristics of the normal kidney are in the shape of an oval composed of the renal cortex, which shows low echo compared to the liver, and the renal sinus, which shows high echo. The boundary between the cortex and the renal sinus is clear, and a high echo in the centre is visible. On the other hand, in the kidney that is continuously damaged, the ultrasonic echo of the renal cortex increases due to fibrosis. As a result, the boundary between the brightened renal cortex and the renal cortex is unclearly observed. In addition, due to the decline in function, the size decreases, and kidney atrophy is observed [14]. Because these features are used in the diagnosis of chronic kidney disease, the ROI area was set to 50×50 and set to 3 locations. The Fig. 4 shows non-chronic kidney disease ultrasound and 5 shows chronic kidney disease ultrasound image.
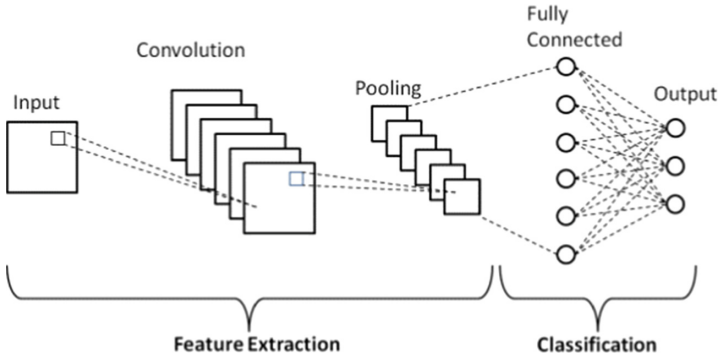
Fig. 3. The overview of chronic kidney disease prediction system using CNN [8].
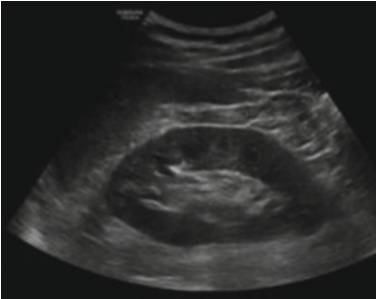
Fig. 4. NCKD
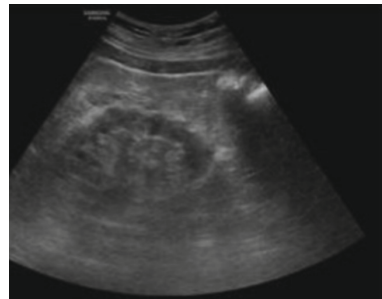
Fig. 5. CKD

6   Conclusion

Early diagnosis and treatment of chronic kidney disease are possible, but as the condition worsens, recovery is unattainable. The use of dialysis or renal replacement therapy is ultimately required. To put it another way, it's critical to identify and manage chronic renal illness as soon as possible. Using information such kidney size and internal echo characteristics, ultrasound is used to examine information on the degree of inflammation when diagnosing kidney cancer, inflammatory diseases, nodular diseases, chronic renal disease, etc.

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