CNN Based Infection Identification in Kidneys Using ECG Signals

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ABSTRACT:

In this study we detect the kidney disease using the ECG signals through the machine learning techniques.The validation for the model was done using data from the aforementioned online database and it was seen that the model could classify most of the patients correctly.Here we are using the proposed method for kidney disease detection is convolutional neural network (CNN).This network eliminates the need for manual feature extraction the features are learned directly by the CNN layers.After completion of feature extraction CNN classifies the train and test data and gives the results as kidney is diseased or not. And class is detected for diseased image. TheChronic Kidney Disease (CKD), or the chronic renal failure, is a disease where the kidneys start to lose their functionality.

Keywords—***Renal Disease, Kidney Failure, Acute Kidney Injury (AKI), Acute Renal Failure (ARF), End Stage Renal Disease (ESRD),Nephrotic Syndrome***

I. INTRODUCTION

Early kidney disease usually doesn't have any symptoms. Testing is the only way to know how well your kidneys are working.Kidney disease occurs when the kidneys cannot function properly. There is not one type of "kidney disease". Rather, a number of different conditions can cause disease and/or a loss in kidney function, and they have different signs and symptoms depending on how they affect the kidneys [1]. A blood test that checks how well your kidneys are filtering your blood, called GFR (glomerular filtration rate). Normal GFR can vary according to age (as you get older it can decrease). The normal value for GFR is 90 or above. A GFR below 60 is a sign that the kidneys are not working properly [2]. Once the GFR decreases below 15, one is at high risk for needing treatment for kidney failure, such as dialysis or a kidney transplant.Creatinine is a waste product that comes from the normal wear and tear on muscles of the body [3]. A creatinine level of greater than 1.2 for women and greater than 1.4 for men may be an early sign that the kidneys are not working properly [1].

Urea nitrogen comes from the breakdown of protein in the foods you eat. A normal BUN level is between 7 and 20. As kidney function decreases, the BUN (Blood urea nitrogen) level rises. Albumin is a protein found in your blood [2]. A healthy kidney doesn't let albumin pass into the urine.Ultrasound test uses sound waves to get a picture of the kidney. It may be used to look for abnormalities in size or position of the kidneys or for obstructions such as stones or tumours. The CT scan imaging technique uses X-rays to picture the kidneys [4]. It may also be used to look for structural abnormalities and the presence of obstructions. This test may require the use of intravenous contrast dye which can be of concern for those with kidney disease.If you have diabetes, get checked every year [5].

When your kidneys stop working suddenly, over a very short period of time (usually two days or less), it is called acute kidney injury (AKI). AKI is sometimes called acute kidney failure or acute renal failure(ARF). It is very serious and requires immediate treatment.Unlike kidney failure that results from kidney damage that gets worse slowly, AKI is often reversible if it is found and treated quickly [2]. If you were healthy

before your kidneys suddenly failed and you were treated for AKI right away, your kidneys may work normally or almost normally after your AKI is treated. Some people have lasting kidney damage after AKI. This is called chronic kidney disease, and it could lead to kidney failure if steps are not taken to prevent the kidney damage from getting worse [1]. Acute kidney or renal failure (ARF) happens when your kidneys suddenly lose the ability to eliminate excess salts, fluids, and waste materials from the blood. This elimination is the core of your kidneys' main function. Body fluids can rise to dangerous levels when kidneys lose their filtering ability [6]. The condition will also cause electrolytes and waste material to accumulate in your body, which can also be life-threatening.

Chronic kidney disease (CKD) is associated with increased risk of cardiovascular disease [7]. Electrocardiographic (ECG) abnormalities are common in CKD patients. However, there is variation in literature regarding frequency of ECG abnormalities in CKD patients and limited information in local population [3].The researches have showed that patients undergoing kidney problems start developing cardiac problems-scientifically known as the Cardio Renal Syndrome (CRS) which can lead to a sudden cardiac arrest in the last stages of their disease [6]. Heart Rate Variability (HRV) in haemodialysis patients, the frequency component of the digital ECG was also found in lower values Since cardio-vascular diseases and the chronic kidney disease is inter-related, this model can be used for patients undergoing cardio-vascular problems to determine whether their kidneys have been effected or not. If the Chronic Kidney Disease (CKD) can be diagnosed at an earlier stage, it may give the patient some time to help reverse the disease or at least slow its progression by taking necessary medical steps [4].

Kidney failure, also called end-stage renal disease (ESRD), is the last stage of chronic kidney disease. When your kidneys fail, it means they have stopped working well enough for you to survive without dialysis or a kidney transplant.Diabetes is the most common cause of ESRD [2]. High blood pressure is the second most common cause of ESRD.Sometimes the kidneys can stop working very suddenly (within two days). This type of kidney failure is called acute kidney injury or acute renal failure [1].The most common primary cause of nephrotic syndrome in adults is a disease called focal segmental glomerulosclerosis (FSGS).If you have high blood pressure, heart disease, or a family history of kidney failure, talk with your health care provider about how often you should get tested. The sooner you know you have kidney disease, the sooner you can get treatment to help protect your kidneys [3].

II. RELATED WORK

The block diagram for existing method is given below.

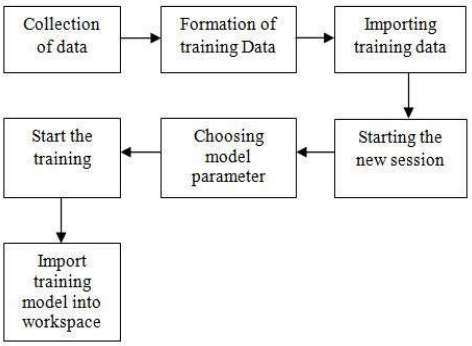

Figure: Block diagram of existing method.

To form the model, the first step was to extract digitalized ECG data from database. As discussed in the previous section, digitized ECG was collected from two

databases - the PTB database for the kidney patients' ECG and the Fantasia database for the healthy elderly patients' ECG as the CKD patients taken form the PTB database were all elderly, to reduce the ageing effect on CVD. The ECGsignals were then processed using the Berger's algorithm, to find the required features- the QT interval and the RR interval. Using the extracted feature from the digitalized ECG, a training set was build where the patients were already labelled as 'kidney' or 'healthy'. Here, the two features act as the predictors while the label is the decision that is expected from the model to make with new unknown data.

MATLAB based application- Classification Learner app was used as for the training and validation of the model. The version of MATLAB used was 2017a since the previous versions might not have the above mentioned application. The created training set was then imported into the Classification Learner application, where the parameters for the model, i.e. the algorithm- linear Support Vector Machine (SVM), features used- QT interval and RR interval, the kernel function- linear, automatic and the cross-validation scheme was selected and the model was trained.It is very important to note that, the supervised machine learning was used because the training data set contained pre-labelled data and the ECG for both groups of patients were already known.

Under supervised machine learning, SVM was chosen because it showed good performance in many studies for classification purposes. For the model, approximately 700 observations for each group were used to design a non-biased model and the cross validation scheme was chosen as the holdout validation with a degree of 50%. The trained model that is returned can be imported into the workspace and it would then appear as a user defined function, which can be used for classifying new unknown data. The trained model, once imported to the workspace was in the form of a function where a new table format data was passed, and the function was used to classify the new data. For the validation of the model, unused data from PTB and Fantasia were again taken and tabulated into another excel file where the features were there but the decision was missing. Once passed through the function, the model delivered the correct decision in a categorical data type.

III. METHODOLOGY

The proposed methodconsists of detection of kidney disease by using theconvolutional neural network (CNN).For the training of the model, all the data was collected from two open access online database, PTB (used for digitized ECG of the kidney patients) and Fantasia (used for the digitized ECG of healthy people) from Physionet database (www.physionet.org). The database each contained two minute long digitalized ECG signal, of the patients, from which the two required features- QT interval and the RR interval was extracted using Berger's algorithm. The patients, whose ECG were taken had an average age between 50 to 70 years old. The following block diagram shows the proposed method for detection of kidney disease.

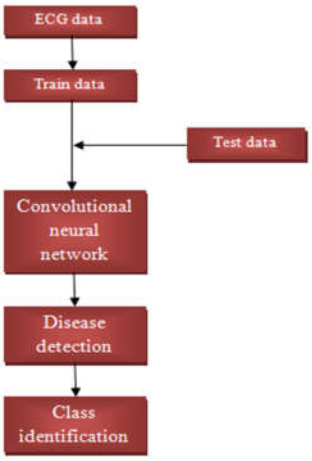

Figure: Block diagram of proposed method.

In deep learning, a convolutional neural network (CNN or ConvNet) is a class of deep neural networks, most commonly applied to analyzing visual imagery. They are also known as shift invariant or space invariant artificial neural networks (SIANN), based on their shared-weights architecture and translation invariance characteristics.Once a CNN is trained, it can be used in real-time applications, such as pedestrian detection in advanced driver assistance systems (ADAS). They have applications in image and video recognition, recommender systems, image classification, medical image analysis, natural language processing, and financial time series.

CNNs are regularized versions of multilayer perceptron. Multilayer perceptron usually mean fully connected networks, that is, each neuron in one layer is connected to all neurons in the next layer. The "fully-connectedness" of these networks makes them prone to over fitting data. Typical ways of regularization include adding some form of magnitude measurement of weights to the loss function. CNNs take a different approach towards regularization: they take advantage of the hierarchical pattern in data and assemble more complex patterns using smaller and simpler patterns. Therefore, on the scale of connectedness and complexity, CNNs are on the lower extreme.

CNNs use relatively little pre-processing compared to other image classification algorithms. This means that the network learns the filters that in traditional algorithms were hand-engineered. This independence from prior knowledge and human effort in feature design is a major advantage.The random forest classification will give the high classification rate and better performance in detecting the disease of kidney.

Procedure:

- First we collect the ECG data from given database.
- Fromthis ECG data we extract the features like QT interval and RR interval.
- These two intervals are called train data which is used for training.
- Convolutional neural network (CNN)is a one of the machine learning technique.
- The system learns to do feature extraction and the core concept of CNN is, it uses convolution of image and filters to generate invariant features which are passed on to the next layer.
- CNNclassifies the train data and test data.
- Finally it gives the results of kidney disease without any misclassification.
- For diseased images it detects the class.

IV. RESULTS AND DISCUSSION

- The below results describe the training process of network.

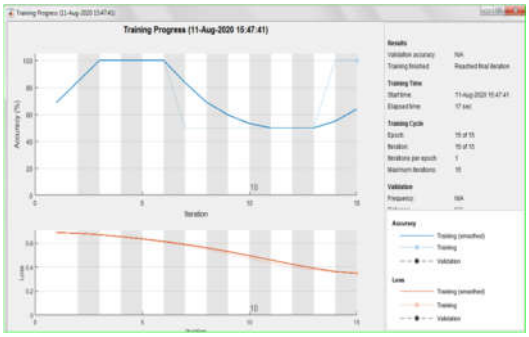

Fig: Training process

- After completion of training process it gives the result as diseased or not. The below dialogue box shows the results for diseased one.

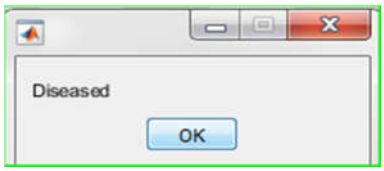

Fig: Disease Detection

- If the kidney is diseased next it detects the class. The below results describe the training process of network for class detection.

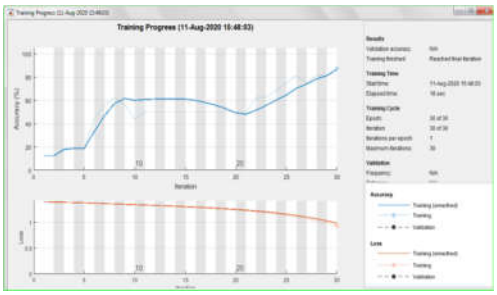

Fig: Training process

- After completion of training process it detects the class for diseased. The below dialogue box shows the class detection results.

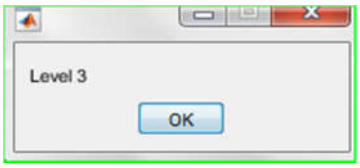

Fig: Level Detection

- Finally we calculate the results for accuracy and specificity.

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Accuracy
   74.7500

Specificity
   91.8797
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Fig: Parameters

- The below table compares the results of existing and proposed methods.

S. No	Existing Method in %	Proposed Method in %
1	70	87.50
2	70	83.50
3	70	83.50
4	70	81.25
5	70	83.50

Table: Accuracy Comparison

V. CONCLUSION

It was concluded that the proposed algorithm detects the kidney disease using the ECG data of signals through machine learning technique. In this we are using the convolutional neural network (CNN) as classifier. It classifies the kidney disease or not. For diseased kidney it detects the class. There is no misclassification. From this the detection of kidney disease is easy and gives better performance.

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