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Prediction of Chronic Kidney Disease Using ML Techniques

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Abstract—The study of chronic kidney disease of human body is now a significant topic of interest in the domain of biosciences because of the emerging cases of the disease. One of the most dangerous illnesses in the modern world is chronic kidney disease, for which an accurate diagnosis method needs to be developed to identify and stop the disease at an early stage. A condition known as chronic kidney disease causes a person's kidneys to malfunction and eventually become damaged. This leads to the condition where the kidney is unable to filter the blood and remove the waste as they do. Now-a-days machine learning algorithms have become a major tool in which the disease gets diagnosed based on the certain values like blood pressure, urine value and many such things. This leads to the early detection of the disease so that the patient can consult his required doctor and with the help of which his disease could be cured. The application and the study of the applied algorithm will help us to detect the disease will be explored in this study. These algorithms' outputs have a higher degree of accuracy, sensitivity, and specificity and can be used to predict the presence of chronic kidney disease in the necessary human being. The findings will demonstrate how technology can aid in the better management of chronic kidney disease and how this can enhance decision support systems for healthcare in general.

Keywords—Machine learning methodologies, Decision tree, SVM, GUI Data-driven detection Smart disease detection

I. INTRODUCTION

Many people face the difficulties of Chronic Kidney Disease (CKD) a health issue where the kidneys do not function optimally and can worsen over time. Detecting CKD early is crucial, for providing care. In years medical professionals and scientists have utilized Machine Learning (ML) a type of computer technology to help predict CKD. ML has shown effectiveness in analysing aspects of an individual's information, such as their history, test results and other relevant details. By using ML techniques doctors can identify individuals who may be at risk of developing CKD before it progresses significantly. This proactive approach allows for intervention. Facilitates the creation of personalized treatment plans by healthcare providers.

In this research paper we explore how ML techniques are transforming the prediction and prevention of CKD. This advancement has the potential to improve the quality of life for people who currently struggle with this condition or its associated complications while also reducing pressure, on healthcare systems.

II. RELATED PREVIOUS WORK

In this literature review we delve into studies that explore the relationship, between machine learning and artificial intelligence (AI) in the medical field specifically focusing on predicting chronic kidney disease. These studies investigate how AI driven apps deep learning and machine learning can potentially revolutionize healthcare by enhancing CKD predictions streamlining procedures and providing cost solutions for hospitals and patients. By analyzing the findings and contributions of each publication this review sheds light on the promising advancements and practical applications of AI technology, in healthcare practices [1] The primary focus of this research paper, by Imesh Udara Ekanayake and Damayanthi Herath, is to identify and predict Chronic Kidney Disease (CKD) at a stage. CKD is a global health concern. It is crucial to detect it early in order to minimize its impact. The authors propose an approach that involves selecting attributes preprocessing the data and addressing missing values to predict the status of CKD based on clinical data.

To assess CKD prediction the authors utilized a dataset in the UCI repository. The study highlights the importance of handling of data selecting features and employing predictive modeling techniques for accurately identifying cases of CKD. The findings suggest that this methodology offers a means for prediction of CKD, which can facilitate timely access to care, for patients.[2] The focus of this research study is to develop a model using algorithms and other techniques for early detection of chronic kidney disease (CKD). Here are the key ideas and conclusions;

- CKD is a condition that can be challenging to identify in its stages due, to the absence of noticeable symptoms. Early diagnosis plays a role in determining treatments like dialysis or kidney transplantation.
- The project aims to create a model that assists clinicians in identifying and treating patients with CKD promoting their well being and helping them comprehend the risks and severity of the illness. Machine learning algorithms are utilized for management and prediction.

- Model Components; The proposed model for identification of CKD consists of three components;

1. Utilizing baseline classifiers that rely on variables.

2. Applying baseline classifiers on both categorical attributes.

3. Combining the output, from these three classifiers through majority voting to enhance model performance.

d) Performance Enhancement; The model proposed in this study, which utilizes majority voting and baseline classifiers demonstrates a 3% increase, in accuracy compared to existing models. This improvement confirms the models ability to categorize kidney disease (CKD) effectively.

e) Significance of Early Detection; Chronic kidney disease (CKD) often progresses silently without any symptoms. Therefore early detection plays a role, in treatment to prevent severe consequences that may lead to fatality.

f). Machine Learning; The study utilizes machine learning algorithms and data mining techniques to predict and manage Chronic Kidney Disease (CKD). The model is trained using data collected from CKD patients with the possibility of enhancing its accuracy through data. By utilizing the estimated Glomerular Filtration Rate (eGFR) the model determines the stage of the patient. Selects the most suitable algorithm to classify CKD or NOT_CKD.

g) Machine Learning Classifiers; This study employs three machine learning classifiers. Support vector machine, forest and artificial neural network. The findings indicate that the Random Forest classifier outperforms the two in terms of accuracy, precision, recall, F score and ROC AUC.

In summary this research work presents a model, for identification of CKD that emphasizes the importance of timely diagnosis and leverages machine learning methods to enhance precision. The Random Forest classifier is identified as the approach. This approach has potential in improving prediction of CKD and facilitating treatment planning, for both patients and medical professionals. To enhance the performance of this model further future work may involve incorporating feature selection techniques and refining the model [3] This research focuses on exploring how data mining and machine learning techniques can be used to detect Chronic Kidney Disease (CKD) at a stage. When a person's kidneys are not able to filter blood as they should it is referred to as chronic kidney disease (CKD). The study examines the importance of detecting CKD as it can significantly improve patients quality of life. Various machine learning techniques, such, as SVM, Random Forest and decision tree algorithms are analyzed for their effectiveness, in predicting CKD.

The study demonstrates the potential of machine learning algorithms, in identifying kidney disease (CKD) at a stage leading to improved patient outcomes. It emphasizes the significance of accuracy when selecting the CKD prognosis model. [4] The research paper titled "Python and Machine Learning, for Predicting Chronic Kidney Disease" written by Naveya Bhutani explores the utilization of machine learning techniques Artificial Neural Networks (ANN) to forecast the occurrence of kidney disease (CKD). The study highlights the importance of detection, in identifying CKD, a dangerous condition that can often remain undiagnosed during its initial stages. It demonstrates how machine learning can aid physicians in achieving diagnoses and emphasizes the significance of accuracy when selecting a CKD prediction model.

Important ideas from the paper:

a) Introduction: Because there are no outward indications of chronic kidney disease, the need of early diagnosis cannot be overstated in this work. Serious repercussions from CKD can include end-stage renal failure. With the use of historical patient data, machine learning models can be used to predict CKD.

b) Literature Review: Prior research on CKD prediction is reviewed, along with the techniques used. These research employ the Multiclass Decision Forest method in conjunction with machine learning classification approaches such as RBF, RF, and Basic Propagation Neural Network to obtain high accuracy in CKD prediction.

c) Dataset and Attributes: The UCI repository provided the dataset used in the study, which comprises 400 patient records with 25 characteristics associated with CKD. The study emphasizes how crucial it is to choose crucial attributes, deal with missing values, and clean and manipulate the dataset.

d) Process: Using Artificial Neural Networks (ANN), the research describes the process for developing the CKD prediction model. Preprocessing of data, encompassing scale, reduction, cleaning, and splitting, is covered. Next, the data is split into testing and training sets.

e) Model Building (ANN): The architecture of the ANN model consists of two layers, the first of which has 256 neurons and an activation function called "ReLu." In the second layer, one neuron has 'hard_sigmoid' activity. 'Adam' is the optimizer and 'Binary_crossentropy' is the loss function used in the compilation of the model. After training, the model is saved.

f) The study reveals that their established model accurately and with good loss and accuracy predicts the occurrence of chronic kidney disease. The ANN-based model can be used as the basis for healthcare systems and the prediction of CKD.

The construction of a machine learning model, specifically an Artificial Neural Network, for To summarize, the primary focus of this paper is the prediction of chronic kidney disease. It covers the methodology, data preparation, model architecture, and possible advancements in CKD prediction in the future [5] A paper by Tomas E Ward and his team studied about the chronic kidney disease. In order to support cost-effectiveness analyses of CKD treatments, this study thoroughly examined economic models that mimic the long-term the effects of kidney disease (CKD) over time. Throughout the review, 101 models were discovered and categorized into four groups: CKD models, diabetes models with nephropathy, ESRD-only models, and cardiovascular models with elements of CKD.

To increase the accuracy of economic modelling in CKD, more investigation is required [6].

TABLE I. COMPARISON OF ALGORITHM

S.no	Authors	Algorithms	Accuracy	Precision	Fi Score
1)	Imesh Udara Ekanayake, Damayanthi Herath	KNN (Semi Supervised Learning Model)	97.85%	1.000	0.987
2)	Saurav Pal	Logistic Regression	93.28%	0.935	0.968
		Decision Tree	95.92%	0.952	0.978
		SVM	94.80%	0.920	0.960
3)	Revathy Ramesh , M.Ramesh	Decision Tree	94.16%	0.948	0.916
4)	Naveya Bhutani	ANN	88.16%	0.901	0.916
5)	Marwa Almasoud , Tomas E Ward	Support vector machines	97.5%	0.959	0.972
		Random forest	96.5%	0.953	0.975
6)	Nikhila	Naive Byes	95.8%	0.945	0.964
7)	I.A. Pasadana , D. Hartama , M. Zarlis, A.S. Sianipar , A. Munandar , S. Baeha, A.R.M. Alam	Random Tree	95.5%	0.956	0.976
8)	Elias Dritsas and Maria Trigka	SVM (linear)	94.0%	0.940	0.940
		ANN	96.8%	0.968	0.968
9)	Reshma S , Salma Shaji , S R Ajina , Vishnu Priya S R , Janisha A	SVM	88%	1.00	0.94
10)	Siddheshwar Tekale , Pranjal Shingavi , Sukanya Wandhekar, Ankit Chatorikar	Decision Tree	95.4%	0.942	0.964
		SVM	94.8%	0.945	0.954

The study "Chronic Kidney Disease Prediction using Machine Learning Ensemble Algorithm" explores the use of machine learning techniques to detect Chronic Kidney Disease (CKD) at a stage. CKD, a health concern affecting individuals is often linked to risk factors such, as diabetes, heart disease and hypertension. Detecting CKD in its stages can be challenging as symptoms may not be apparent. However one approach that shows promise is the application of machine learning. In this study four ensemble algorithms (bagging, random forest and gradient boosting) were employed to develop models for CKD. Performance indicators, like F1 score were used for evaluation.

When comparing the results it was found that AdaBoost and Random Forest outperformed Gradient Boosting and Bagging in terms of accuracy, precision, sensitivity and other factors. The study highlights that AdaBoost and Random Forest demonstrated their effectiveness in predicting CKD at a stage based on their Mathew Correlation Coefficient and Area Under the Curve scores [7] In the research paper titled "Utilizing Decision Tree Techniques, for Predicting Chronic Kidney Disease " the authors explore the application of different decision tree algorithms to predict this ailment. They utilize the CKD dataset obtained from UCI, which encompasses attributes such, as age, blood pressure, specific gravity, albumin, sugar levels and other health indicators. The main objective is to evaluate the effectiveness of multiple decision tree algorithms in predicting kidney disease (CKD) and analyzing their performance.

The researchers have examined eleven algorithms, for decision trees, HoeffdingTree, J48, CTC, J48graft, LMT, NBTree, RandomForest, RandomTree, REPTree and SimpleCart. These methods were evaluated based on performance metrics like Runtime, F Measure, Mean Absolute Error, Precision, Accuracy and Kappa Statistics. The findings indicate that RandomForest stands out as the classifier for predicting CKD with a remarkable accuracy rate of 100%. While J48graft and NBTree also demonstrated accuracy rates along with J48 being close behind them. On the hand DecisionStump had the accuracy rate of 92%. Additionally the publication also delves into the runtime performance of each approach. The study highlights the importance of data mining techniques in managing and predicting CKD. It suggests that early detection of CKD can be greatly facilitated by utilizing decision tree techniques such as Random Forest. Furthermore it advocates for developing advanced decision tree algorithms for CKD diagnosis and conducting research using up to date data from diverse regions. This study contributes to our understanding of machine learning algorithms for identification which plays a crucial role, in improving patient survival rates in cases of CKD.

In this study researchers utilized a dataset consisting of 400 records and 25 variables related to Chronic Kidney Disease (CKD). However they only considered 14 characteristics when building their prediction model. To make predictions they employed two machine learning techniques; Decision Trees and Support Vector Machines (SVM). The analysis revealed that SVM outperformed Decision Trees with an accuracy rate of 96.75%. Precise forecasts are essential for prompt diagnosis and management, enabling medical practitioners to treat CKD patients appropriately and possibly preventing fatalities.

The study admits its shortcomings, one of which being the requirement for larger datasets devoid of missing values in order to increase prediction accuracy. The study also outlines the possibilities for further research in this field, including the application of deep learning methods to improve CKD prediction even more. In conclusion, this study sheds light on the use of machine learning to predict CKD, which has substantial advantages for both patients and the healthcare system.

III. METHODOLOGY

The methodology for developing a CKD prediction model using machine learning techniques involves several common steps which are-

a) Data Collection- The first step is to collect a high-quality dataset. The dataset should contain demographic data, medical history, and laboratory results for both CKD patients and healthy controls.

b) Data Preprocessing- In we basically do processing on the data like handling missing values, dropping unnecessary features, remove outliers,scale the data to a common scale, etc.

c) Feature Engineering- In this we selected important and necessary features which are needed for chronic kidney disease prediction like some of them are- age, gender, blood pressure,

sugar, family history, haemoglobin, urine protein, cholesterol level, serium creatinine.

d) Model Development-In this we use algorithms to train our model.

e) Model Evaluation- Following model development, assess each model's performance using the F1 score, accuracy, and precision.

f) Best Model Selection- This is the last step in this we select the model with the best accuracy for predicting the chronic kidney disease.

g) Development of User Interface: The algorithms employed in this

1)SVM

2)KNN

3)Random Forest

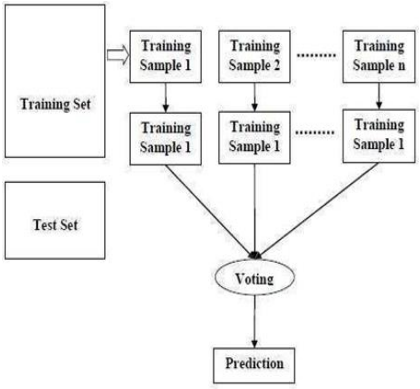

Fig. 1. SVM

Support for SVM A supervised learning technique that can be applied to both regression and classification problems is the vector machine (SVM). SVMs function by locating a hyperplane in the data that has the greatest margin of separation between the various classes. The margin is the separation between the nearest data points for each class and the hyperplane, which is a flat surface in a multidimensional space.

SVMs work particularly well in situations involving high-dimensional data and noisy or sparse data. Even with little training data, they continue to function well. Spam filtering, image classification, text classification, and other applications have all seen success with SVMs.

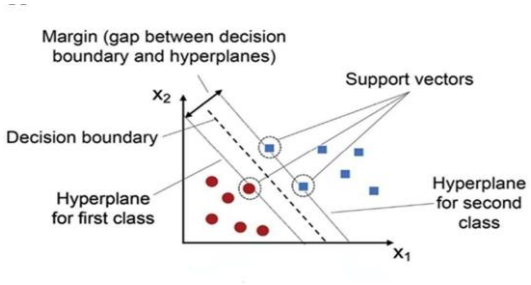

Fig. 2. KNN

A supervised machine learning algorithm called K-Nearest Neighbors (KNN) can be applied to regression and classification problems. In order for KNN to predict the label or value of a new data point, it first determines which K data points in the training set are the most similar to the new data point. Then, it uses the labels or values of those K data points.

KNN is such a simple type of the algorithm, yet effective algorithm that is easy in order of implement and can be used with any type of data. It is especially well-suited for problems where the data is noisy or sparse. One important hyperparameter for KNN is the number of nearest neighbors to be used for prediction, denoted by the value of K. The algorithm's performance can be significantly affected by the choice of K, so it's critical to adjust K for each unique problem.

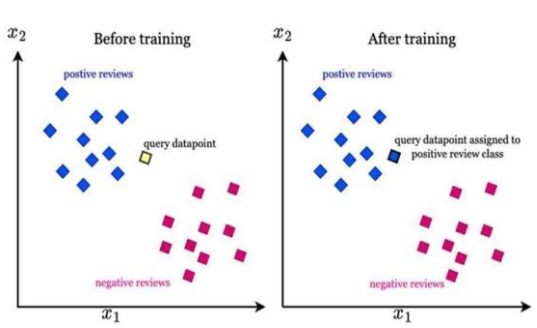

Fig. 3. Random forest

This is a supervised algorithm for the process of the classification and for the process of the regression. It constructs multiple decision trees using bootstrapping and feature bagging, and predicts the output by the means of the averaging the predictions of the individual trees. RF is easy to implement and tune, and is especially well-suited for high- dimensional data and problems where the data is noisy or incomplete.

IV. Implementation

a) Problem statement: To build a model for the timely prediction of chronic kidney disease can be achieved with optimal accuracy by utilizing multiple machine learning algorithms.

b) Data: The foundation of predicting the chronic kidney disease mainly relies on the high quality of the dataset which will be used in the development of the project. Custom built dataset has been taken into account for prediction of the CKD, suggesting and ensuring that the information provided to us is relevant and reliable and could be used further. To ensure data accuracy and consistency, data collection involved painstaking procedures for gathering, cleaning, and preparation. The effectiveness of the system is further enhanced by external data sources, such as weather data, which offer crucial information for decision-making.

c) Frontend: A user-friendly website acts as the interface between users and the main features of the chronic renal disease prediction system. The interface has been created in a way that allows users to provide pertinent data before more predictions are made.

d) Data science: With the help of the data science , the diagnosis as well as the treatment of the chronic kidney disease have been done very easily and it has been done up to a greater extent. This have been done by providing the medical records to the machine learning analyser. With the help of these records a machine learning model was easily made with a good accuracy and was then used to detect and cure the disease.

V. DATASET

The dataset for this project has been taken from Kaggle and other survey from the hospitals. This dataset includes characteristics like age, blood pressure, serum creatinine, and diabetes status, among other clinical and laboratory values for individuals. These characteristics can be useful building blocks for prediction models.

With the help of this dataset, we can predict this disease as it has the ability to provide the highest level of accuracy.

The dataset has 400 rows and 25 columns.

Description of Attributes in the Dataset.

Sr. No	Attribute Name	Description
1	Age	Patient age (It is in years)
2	Bp	Patient blood pressure (It is in mm/HG)
3	Sg	Patient urine specific gravity
4	Al	Patient albumin ranges from 0-5
5	Su	Patient sugar ranges from 0-5
6	Rbc	Patient red blood cells two value normal and abnormal
7	Pc	Patient pus cell two value normal and abnormal
8	Pcc	Patient pus cell clumps two values present and not present
9	Ba	Patient bacteria two values present and not present
10	Bgr	Patient blood glucose random in mg/dl
11	Bu	Patient blood urea in mg/dl
12	Sc	Patient serum creatinine
13	Sod	Patient sodium
14	Pot	Patient potassium
15	Hemo	Patient hemoglobin (protein molecule in red blood cells)
16	Pcv	Patient packed cell volume % of red blood cells in circulating blood
17	Wc	Patient white blood cell counts in per microliter
18	Rc	Patient red blood cell count in million cells per microliter
19	Htn	Patient hypertension two value Yes and No
20	Dm	Patient diabetes mellitus two value Yes and No
21	Cad	Patient coronary artery disease two value Yes and No
22	Appet	Patient appetite two value good and poor
23	Pe	Patient pedal edema two value Yes and No
24	Ane	Patient anemia two value Yes and No
25	Class	Target Variable (CKD or Not)

VI. EXPERIMENTAL SETUP

a) Step to create the model:

Step 1: Firstly, we have to decide about the object which have to be delivered at the compilation of the project and before the publication of the following research paper.

Step 2: After the first step we need to identify the people and the area which will benefit after the paper gets published and the after the given project gets deployed.

Step 3: Thirdly we need to take care about the scope of the project and then we need to define the scope of the project accordingly along with the features which have to be taken care and the functionality of each and every component of the project and the paper.

Step 4: About the above steps have been completed, then in fourth step we need to collect the data so that we can define and prepare our dataset and then could select a proper model and further develop the project.

Step 5: Further in this step we use the jupyter notebook in order to find and perform the prediction on the dataset and to implement the perfect model.

Step 6: In this step, the machine learning model which has been created is now evaluated and them is validated on the basis of the dataset.

Step 7: In this step, we the backend is developed so that it can be connected with the user interface which have to be build.

Step 8: Here we will be developing the frontend of the application using React JS and other frontend frameworks. Step 9: In this phase we will integrate the flask connectivity API with the React JS frontend.

Step 10: Finally, after the completion of the development of the project we will deploy the project on cloud platform.

Tools and Technologies used-

1) Python

2) Machine Learning

3) Jupyter Notebook

4) Flask

VII. RESULT

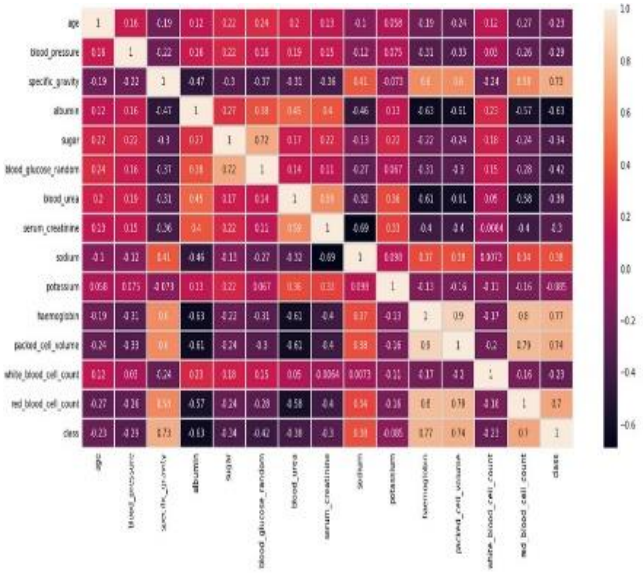

Fig. 4. Heatmap for the distribution

TABLE II. MODEL COMAPRISION

S.No.	Algorithm Used	Accuracy
1.	SVM	60%
2.	KNN	70%
3.	Decision Tree Classifier	97.5%
4.	Random Forest Classifier	98.33%

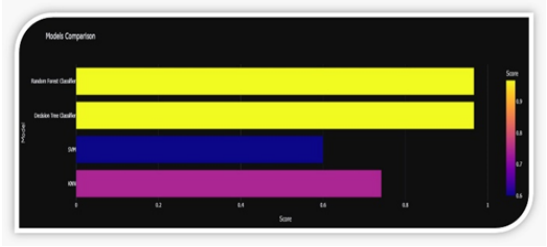

Fig. 5. Charts

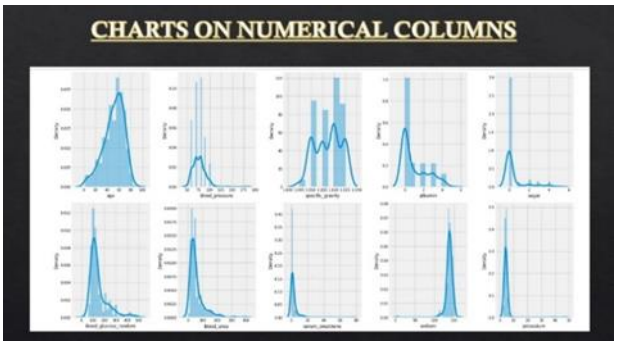

Fig. 6. Charts on Numerical Columns

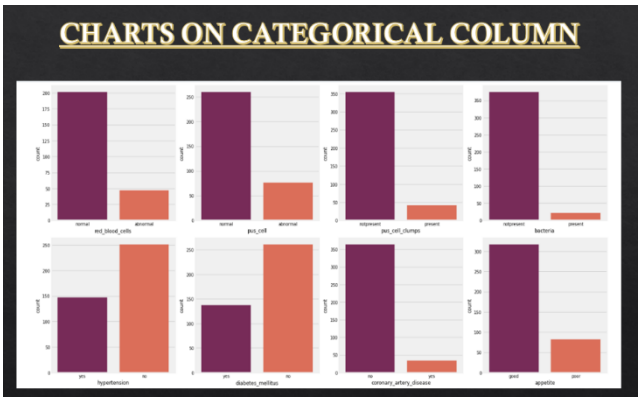

Fig. 7. Charts on Categorical Column

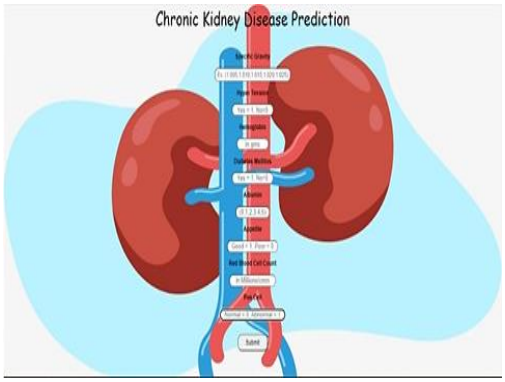

Fig. 8. Kidney Disease Prediction

VIII. CONCLUSION

To sum up it can be said that, the use of machine learning techniques in order to forecast the this disease is a great step which can be used in the field of the medical world. With the help of these algorithms we can make early identification of the disease , can perform risk assessment and give the patients their customized reports with the help of the various data analysing tools. With the help of this product the doctors can easily manage and allocate the resources and can easily track the behaviour of this disease such that other patients may not get any chance to have this disease. With the help of the machine learning models we can do the remote monitoring of the disease which can increase the quality of life of the patients who are suffering from this disease.

We cannot underestimate the contribution of the various machine learning models which have been used in the development of the product. These models have improved the diagnosis time and the accuracy which have helped the doctors to manage the illness much effectively.

IX. FUTURE SCOPE

The aspect of utilising the machine learning techniques in order to forecast Chronic Kidney Disease (CKD) presents the optimizing for the accurate early detection and customised result predictions. Better results may ultimately result from this. The model which will be made will reduce the burden on healthcare systems and suggest the closest doctor in your area.

X. DELIVERABLES

The given below are the list of the deliverables which we can expect after the completion of the project:

1. The project will provide us with the machine learning models that are designed in order to predict the likelihood of the disease. They can also provide us with the feature of the risk assessments and the will also give the early warnings to the patients.

2.The model will provide us with the tools which will be used to diagnose the disease and will improve the performance.

3.The model will provide us with the calculate risk ratings that will help the user to know the severity of the chronic kidney disease. This early assessment can help in the early detection and hence saving lives.

4.The model will give the graphs and the certain reports which can be used by the doctor to check whether the disease is severe or not. This will help the doctor to give his patient a better suggestion so that the disease could be cured.

6. With the help of this project we can generate several educational materials which intends to educate the patient as well as the common people such that they may know the reasons because of which they can be affected by this disease. It can also be used by doctors to study the disease so that they can give a better consultation to any of their patients whom they think that they could be affected by this disease.

7.This project made can be used to make the remote monitoring systems with the help of which the doctors can check the medical condition of their patients at any time and at any place.

The above are the given set of deliverables which can be achieved when the project is made completely. These will facilitate the early detection of the disease, care of the patients, real time feedbacks and the overall outcomes in the treatment of this disease.

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