

EARLY DETECTION OF CHRONIC KIDNEY DISEASE USING MACHINE LEARNING

PROJECT REPORT

Submitted by

TEAM ID: PNT2022TMID00708

PRAVEENKUMAR K	211419104198
SUNDARESWAR N	211419104274
SARATH S	211419104238
RAMAKRISHNAN	211419104208

in partial fulfillment for the award of the degree

of

BACHELOR OF ENGINEERING

in

COMPUTER SCIENCE AND ENGINEERING



PANIMALAR ENGINEERING COLLEGE

(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEC 2022

DECLARATION BY THE STUDENT

We **PRAVEENKUMAR K (211419104198), SUNDARESWAR N (211419104274), SARATH S (211419104238), RAMAKRISHNAN (211419104208)** hereby declare that this project report titled "**EARLY DETECTION OF CHRONIC KIDNEY DISEASE USING MACHINE LEARNING**", under the guidance of **P. VIJAYALAKSHMI**, is the original work done by us and we have not plagiarized or submitted to any other degree in any university by us.

CHAPTER NO.	TITLE	PAGE NO
1	INTRODUCTION	1
	1.1 PROJECT OVERVIEW	1
	1.2 PURPOSE	2
2	LITERATURE SURVEY	2
	2.1 EXISTING PROBLEM	2
	2.2 REFERENCES	3
	2.3 PROBLEM STATEMENT DEFINITION	8
3	IDEATION & PROPOSED SOLUTION	11
	3.1 EMPATHY MAP CANVAS	11
	3.2 IDEATION & BRAIN STORMING	12
	3.3 PROPOED SOLUTION	17
	3.4 PROBLEM SOLUTION FIT	19
4	REQUIREMENT ANALYSIS	20
	4.1 FUNCTIONAL REQUIREMENTS	20
	4.2 NON – FUNCTIONAL REQUIREMENTS	21

5	PROJECT DESIGN	22
	5.1 DATA FLOW DIAGRAM	22
	5.2 SOLUTION & ARCHITECTURE	23
	5.3 USER STORIES	26
6	PROJECT PLANNING & SCHEDULING	31
	6.1 SPRINT PLANNING & SCHEDULING	31
	6.2 SPRINT DELIVERY SCHEDULE	33
	6.3 REPORT FROM JIRA	34
7	CODING & SOLUTIONING	40
	7.1 FEATURE 1	41
	7.2 FEATURE 2	60
	7.3 FEATURE 3	64
	7.4 FEATURE 4	71
8	TESTING	95
	8.1 TEST CASES	95
	8.2 USER ACCEPTANCE TESTING	97

9	RESULTS	99
	9.1 PERFORMANCE METRICS	99
10	ADVANTAGES & DISADVANTAGES	101
11	CONCLUSION	101
12	FUTURE SCOPE	102
13	APPENDIX	102

APPLIED DATA SCIENCE

Early Detection Of Chronic Kidney Disease Using Machine Learning

1.0 INTRODUCTION

Chronic kidney disease prediction is one of the most important issues in health care-analytics. The most interesting and challenging tasks in day-to-day lives as one third of adult population is affected by chronic kidney disease (CKD), and millions die each year because they do not have access to affordable treatment. Chronic Kidney Disease can be cured, if treated in the early stages. The main aim of the project is to predict whether the patient have chronic kidney disease or not in a painless, accurate and faster way based on certain diagnostic measurement like Blood Pressure(BP), Albumin(AL) etc., and then appropriate treatment can be given based on the details provided by the model.

1.1 Project Overview:

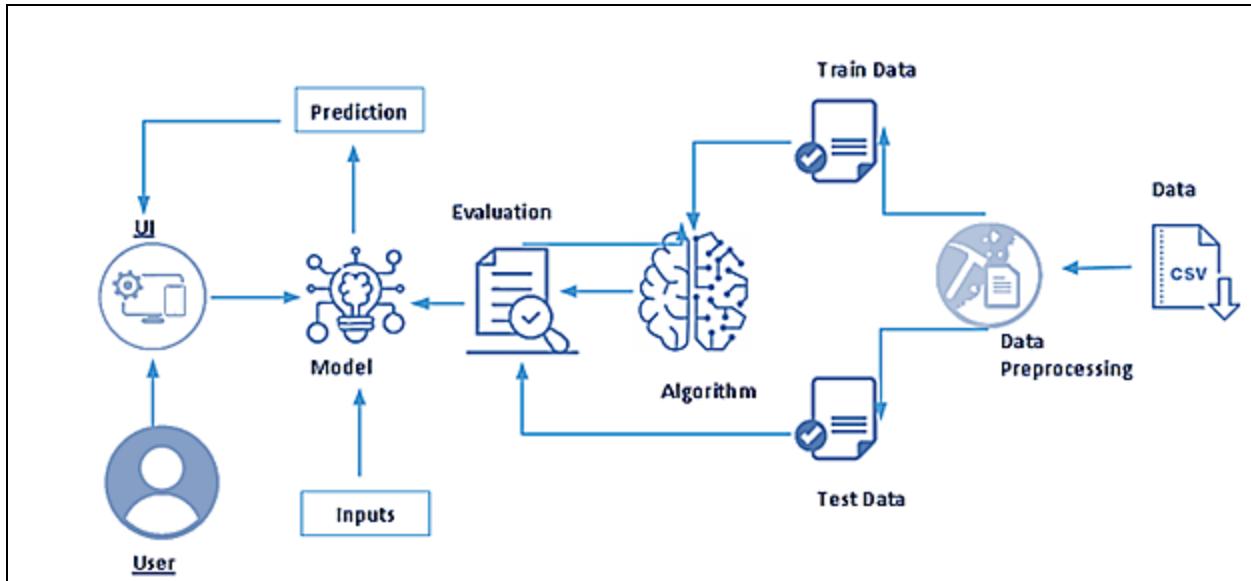
This Project aims at creating a model for early detection of Chronic Kidney Disease using Machine Learning technology. The model output is integrated with Flask framework. The front end developed in html is used to receive user input on various parameters needed to decide on the early detection of kidney disease. The same model is deployed into IBM cloud using API keys and scoring endpoints.

Skills Required:

- Python
- Python For data Visualization
- Python-Flask
- IBM Cloud

- Data Preprocessing Techniques

Architecture:



In this project we have followed the entire software development life cycle process using agile methodology.

1.2 Purpose:

The purpose of the project is to alert patients of an early chance of a kidney disease and hence ensure speedy recovery or prevention of kidney disease.

2.0 LITERATURE SURVEY

2.1 Existing Problem:

There are a large number of people in the world who gets affected to kidney related diseases. Our country India ranks first in terms of people getting affected by kidney related disease. Though population plays a major factor in it, the fact that China which has higher population than us is actually ranking in a much lower place than us in the term of people getting affected by kidney related disease. Generally, the kidney diseases

are caused by the abnormal physiological functionalities of human kidney. Therefore, the characteristic symptoms are generated based on the differentiation between normal physiological functionalities and abnormal physiological functionalities of the kidney. The difference in the functionality of kidney is mainly due to the lifestyle and the food preference people have in their life. So the reason we were doing this project is to find the symptoms of kidney related diseases for the users and alert them before the disease becomes fatal for the patient. The main motive of this project is to find the symptom and its cure as soon as possible.

2.1 References:

1	February 12, 2019	Detailed Review of Chronic Kidney Disease	Yesubabu Kakitapallia, Janakiram Ampolua, Satya Dinesh Madasa, M.L.S. Sai Kumar	https://www.karger.com/Article/Pdf/504622
---	-------------------	---	---	---

The proposed method is used to explain about the effects of kidney diseases. In this method Kidney damage can be assessed by albumin creatinine rate (ACR); albuminuria is one of the identifiers of kidney function in a timed urine collection. It was stated that one of the reasons for CKD, i.e., excretion of proteinuria, which is due to the intake of cooked meat or increased intake of protein or any kidney infection.

2	October 1, 2019	Chronic Kidney Disease Diagnosis and Management	Teresa K. Chen, MD, MHS, Daphne H. Knicely, MD, and Morgan E Grams, MD, PhD	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7015670/
---	-----------------	---	---	---

The proposed system uses CKD method for diagnosis. In this method once a diagnosis of CKD has been made, the next step is to determine staging, which is based on GFR, albuminuria, and cause of CKD . Staging of GFR is classified as G1 (GFR ≥ 90 ml/min/1.73 m²), G2 (GFR 60–89 ml/min/1.73 m²), G3a (45–59 ml/min/1.73 m²), G3b (30–44 ml/min/1.73 m²), G4 (15–29 ml/min/1.73 m²), and G5 (<15 ml/min/1.73 m²).

3	27 November 2013	Risk factors for chronic kidney disease: an update	Rumeysa Kazancio glu	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4089662/
---	------------------	--	----------------------	---

This system explains about inheritance in the kidney disease such as Uromodulin. It is another identified mutation is related to APOL1. An autosomal recessive pattern of inheritance is demonstrated and associated with a substantially higher risk of ESRD (10-fold higher risk of ESRD due to focal glomerulosclerosis and 7-fold higher risk of ESRD due to hypertension).

4	31 December 2014	Systems biology towards novel chronic kidney disease diagnosis and treatment.	Dr. Bernd Mayer	https://cordis.europa.eu/docs/results/241/241544/final1-syskid-final-report-2015-03-13.pdf
---	------------------	---	-----------------	---

This system explains about the hemodynamic in our glomerulus. Alterations in glomerular hemodynamic were considered of upmost importance. Both afferent arteriolar glomerular vasodilatation and efferent vasoconstriction increase intra-glomerular filtration pressure thus leading to hyper filtration, which on the short term

stabilizes GFR but on the long term leads to progressing glomerular sclerosis thereby initiating a vicious cycle.

5	June 2020	Chronic kidney disease: prevalence and risk factors.	A.M. Aringazina, O.Zh.Narmanova, G.O. Nuskabaeva, Zh.A. Tagaevaq	https://www.researchgate.net/publication/342930212_Chronic_kidney_disease_prevalence_and_risk_factors_literature_review
---	-----------	--	--	---

This system explains about the disease risks and affects that has on us and our surrounding. It also explains about the ill factor it might have and chances of spreading to anyone in our surrounding.

6	July 2011	The Burden of Chronic Kidney Disease on Developing Nations: A 21st Century Challenge in Global Health	Nugent R.A, Fathima S.F., Feigl A.B, Chyung D	https://www.karger.com/Article/Fulltext/321382
---	-----------	---	---	---

The proposed system explains about the ill effects these kidney diseases have on developing countries. In developing nations, the growing prevalence of chronic diseases such as chronic kidney disease has severe implications on health and economic output. The rapid rise of common risk factors such as diabetes, hypertension, and obesity, especially among the poor, will result in even greater and more profound burdens that developing nations are not equipped to handle.

7	FEBRAURY ,2020	A Comparative Analysis of Machine Learning Techniques	Alvaro Sobrinho, Andessa C.M. Da Silveira, Leandro Dias da Silva, Evandro de B. Costa	https://www.researchgate.net/publication/339014686_Computer-Aided_Diagnosis_of_Chronic_Kidney_Disease_in_Developing_Countries_A_Comparative_Analysis_of_Machine_Learning_Techniques
---	----------------	---	---	---

This system explains about the use of diagnosing with the help of computer. Software systems have been developed to assist physicians during CKD monitoring and diagnosis. For example, CKD-Go1is a web application (app) to help users verify their kidney function by inputting their ACR and GFR.

8	January 2018	Diagnosis of Kidney Conditions Using Low-Cost Paper Diagnostics	Md. Nazibul Islam	https://www.researchgate.net/publication/325499924_Diagnosis_of_Kidney_Conditions_Using_Low-Cost_Paper_Diagnostics
---	--------------	---	-------------------	---

This proposed system uses Low cost paper diagnosis method. The method Paper diagnostic devices (PADs) can play a vital role in low-cost and rapid diagnosis of kidney condition, resulting in early detection of kidney complications. Paper diagnostics are paper and cellulose based analytical devices capable of qualitative or quantitative detection of biomarkers.

9	December 2019	Machine Learning Applied to Kidney Disease Prediction: Comparison Study	Akm Shahriar Azad Rabby, Rezwana Mamata, Monira Akter Laboni, Ohidujjaman	https://www.researchgate.net/publication/338356158_Machine_Learning_Applyied_to_Kidney_Disease_Prediction_Comparison_Study
---	---------------	---	---	---

The proposed system uses applied machine language for early detection of kidney disease. The main aim is to find an optimized and efficient machine learning (ML) technique that can effectively recognize and predict the condition of chronic kidney disease. the data has been divided into two sections. In one section train dataset got trained and another section got evaluated by test dataset. The analysis results show that the Decision Tree Classifier and Gaussian Naive Bayes achieved the highest performance than the other classifiers, obtaining the accuracy score of 100% and 1 recall(Sensitivity) score.

10	January 2022	Development of a Graphical User Interface Software for The Prediction of ChronicKidney Disease	S.C. Nwaneri and H.C. Ugo	https://www.ajol.info/index.php/njt/article/view/225270/212516
----	--------------	--	---------------------------	---

The proposed system explains about the training and development of model for kidney diagnosing. This process involves building the neural network architecture and determining the activation functions to be used at the output of each layer of the network. The ANN model is built using the Keras libraries in python. Dense is used to assign the number of layers for the network. The ANN model consists of 25 neurons in the input layer and one neuron at the output layer.

2.3 Problem Statement Definition:

The first step in the problem-solving process is to determine what the problem actually is. This is an important step because you can waste time solving the wrong problem. Do not assume automatically you know what the problem is, because it may not be apparent.

The problem statement is a structured set of statements that describe the purpose of an effort in terms of what problem it's trying to solve.

There are a large number of people in the world who get affected by kidney related diseases. Our country India ranks first in terms of people getting affected by kidney related disease. Though population plays a major factor in it, the fact that China which has higher population than us is actually ranking in a much lower place than us in the term of people getting affected by kidney related disease. Generally, the kidney diseases are caused by the abnormal physiological functionalities of human kidney. Therefore, the characteristic symptoms are generated based on the differentiation between normal physiological functionalities and abnormal physiological functionalities of the kidney. The difference in the functionality of kidney is mainly due to the lifestyle and the food preference people have in their life. So the reason we were doing this project is to find the symptoms of kidney related diseases for the users and alert them before the disease becomes fatal for the patient. The main motive of this project is to find the symptom and its cure as soon as possible.

Who does the problem affect?	Persons who are more than 50 years old or persons who live in a place which has large number of radioactive particles like Japan and those who have hereditary transaction of CKD in their family.
What are the boundaries of the problem?	People who are in ill health due to Kidney Disease and are in the verge of death.
What is the issue?	If a human kidney is affected due to external or hereditary factors then there is a chance of the person to die or have a serious sickness in the future.
When does the issue occur?	If a person's kidney activity is been degraded from the past due to mutation in its cell then Chronic Kidney Disease occurs.
Where does the issue occur?	The issue occurs in the Kidney of the Patient.
Why is it important that we fix the Problem?	It is a life or death matter as any loss of time can result as a dangerous outcome to the patient.
What solution to solve this issue?	An automated system is introduced to identify different diseases in kidney by checking the symptoms shown in the Kidney of the patient.

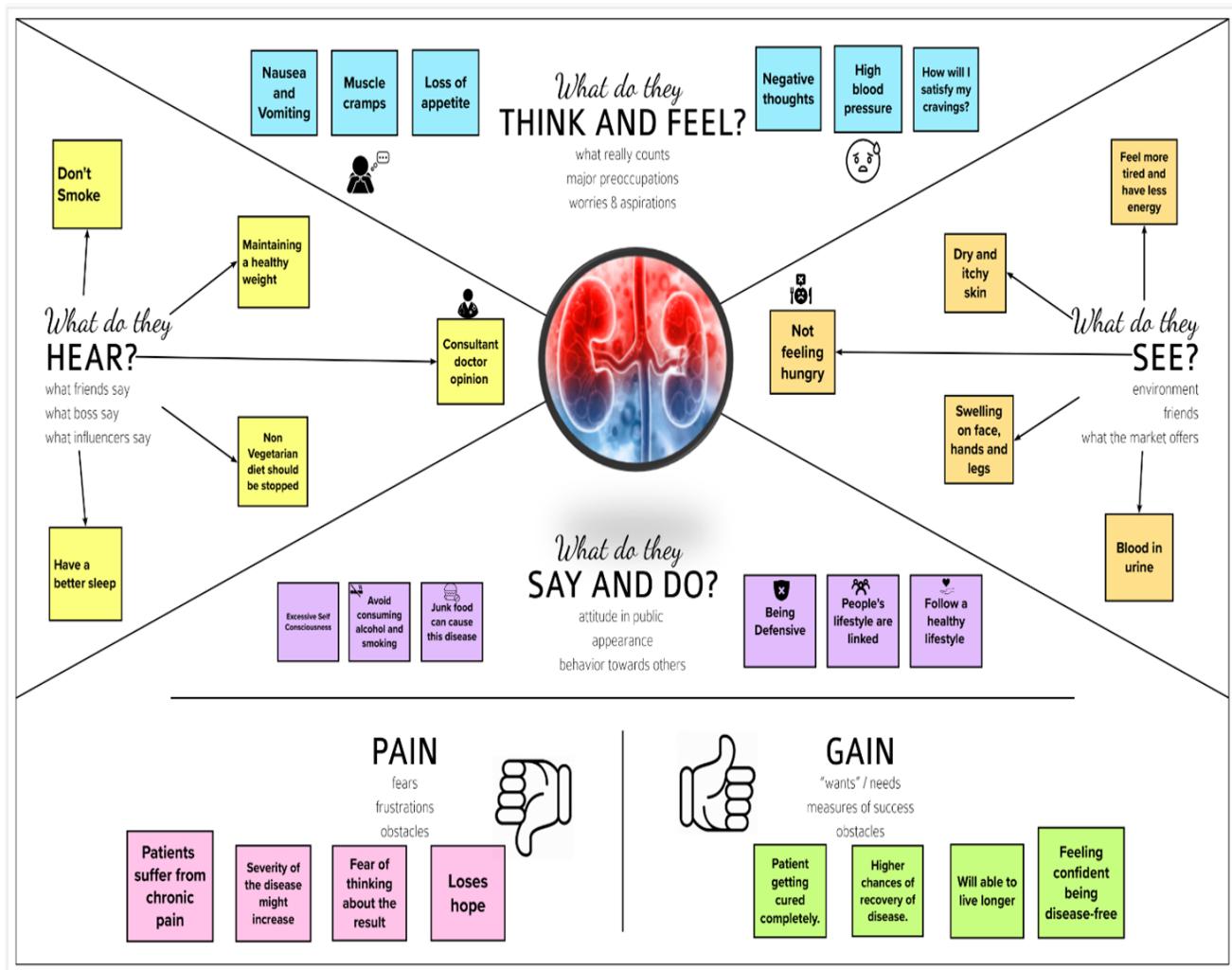
What methodology used to solve the Issue?	Machine learning techniques are used to identify the diseases and suggest the precautions that can be taken for those diseases.
---	---

3.0 IDEATION & PROPOSED SOLUTION

3.1 Empathy Map Canvas:

An empathy map is a collaborative visualization used to articulate what we know about a particular type of user. It externalizes knowledge about users in order to 1) create a shared understanding of user needs, and 2) aid in decision making.

An empathy map helps to map what a design team knows about the potential audience. This tool helps to understand the reason behind some actions a user takes deeply. This tool helps build Empathy towards users and helps design teams shift focus from the product to the users who are going to use the product.



3.2 Ideation & Brainstorming:

Brainstorming is an activity that will help you generate more innovative ideas. It's one of many methods of ideation—the process of coming up with new ideas—and it's core to the design thinking process.

Brainstorming refers to a problem-solving technique used by teams or individuals. In this process, participants generate various ideas or solutions, then begin discussing and narrowing them down to the best options.

Ideation is often closely related to the practice of brainstorming, a specific technique that is utilized to generate new ideas. A principal difference between ideation and brainstorming is that ideation is commonly more thought of as being an individual pursuit, while brainstorming is almost always a group activity. Ideation is the process where you generate ideas and solutions through sessions such as Sketching, Prototyping, Brainstorming, Brain writing, Worst Possible Idea, and a wealth of other ideation.

Rules of Brainstorming



Defer Judgment



Encourage Wild Ideas



Build on the Ideas of Others



Stay Focused on the Topic



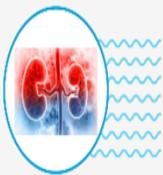
One Conversation at a Time



Be Visual



Go for Quantity



Early Detection of Chronic Kidney Disease

- ✓ Chronic kidney disease (CKD) is a worldwide public health problem. Patients with ESKD consume a disproportionate share of health care resources and experience significant mortality and morbidity and a reduced quality of life.
- ✓ Identifying and managing patients who have early stages of CKD may slow or prevent the progression to ESKD and reduce cardiovascular complications.

1

Before you collaborate

A little bit of preparation goes a long way with this session. Here's what you need to do to get going.

10 minutes

A Team gathering

Define who should participate in the session and send an invite. Share relevant information or pre-work ahead.

B Set the goal

Think about the problem you'll be focusing on solving in the brainstorming session.

C Learn how to use the facilitation tools

Use the Facilitation Superpowers to run a happy and productive session.

[Open article →](#)

1

Define your problem statement

What problem are you trying to solve? Frame your problem as a How Might We statement. This will be the focus of your brainstorm.

5 minutes

PROBLEM
Early Detection of Chronic Kidney Disease



Key rules of brainstorming

To run a smooth and productive session

- | | |
|-----------------|-------------------------|
| Stay in topic. | Encourage wild ideas. |
| Defer judgment. | Listen to others. |
| Go for volume. | If possible, be visual. |

2

Brainstorm

Write down any ideas that come to mind that address your problem statement.

⌚ 10 minutes

PraveenKumar K

Using medical history of patients immediate family and ancestors to predict the kidney disease and the severity

To collect day to day routine of the patient and predict the future chance any kidney disease

A handy device to do a urine test to check for albumin from the comfort of home. Albumin is a protein that can pass into the urine when the kidneys are damaged

Using machine learning techniques to get a accurate results

A handy device to do a blood test that checks how well your kidneys are filtering your blood, called GFR from the comfort of home. GFR stands for glomerular filtration rate.

Sarath S

We could use ph finder to predict how long the patient is affected by kidney disease

We could prescribe specialized doctors to patients near him/her

we could add steps needed to be taken by the users to prevent the further spread of kidney disease.

We could use data interpretation techniques to find the success rate in curing the disease

creating a website to provide awareness about diagnosis and prevention of kidney disease

Sundareswar N

Machine learning is a powerful tool for understanding and diagnosing chronic kidney disease

Chronic kidney disease can be detected with regular laboratory tests, and some treatment which can slow down the disease progression and risk of cardiovascular disease.

The prediction is necessary to combat with the disease and provide good treatment to the patient.

By using the machine learning techniques like Ant Colony Optimization algorithm in CKD used to find the optimal paths in chronic kidney disease.

By given medical historical data and diagnostic data of a patient, Machine learning and Data Discovery approach can help identify risk of CKD at initial stage.

Ramakrishna puttagunta

To develop a hardware which act as sensor to sense abnormalities in kidney.

Machine learning algorithms can be used to identify patterns for early detection of CKD and it better to understand the disease progression.

By using machine learning to analyze data which provide large information of CKD.

Advanced machine-learning algorithms and Deep Neural Networks were utilized in the process of feature selection and model building.

Machine learning can help us understand which factors are associated with an increased risk of CKD.

3

Group ideas

Take turns sharing your ideas while clustering similar or related notes as you go. Once all sticky notes have been grouped, give each cluster a sentence-like label. If a cluster is bigger than six sticky notes, try and see if you can break it up into smaller sub-groups.

⌚ 20 minutes

Category 1: Creating website

We could add steps needed to be taken by the users to prevent the further spread of kidney disease.

Creating a website to provide awareness about diagnosis and prevention of kidney disease.

We could prescribe specialized doctors to patients near him/her.

Category 2: Developing Hardware

To develop a hardware which act as sensor to sense abnormalities in kidney

A handy device to do a blood test that checks how well your kidneys are filtering your blood, called GFR from the comfort of home. GFR stands for glomerular filtration rate.

A handy device to do a urine test to check for albumin from the comfort of home. Albumin is a protein that can pass into the urine when the kidneys are damaged.

Category 3: Laboratory Techniques

We could use pH finder to predict how long the patient is affected by kidney disease.

Chronic kidney disease can be detected with regular laboratory tests, and some treatments which can slow down the disease progression and risk of cardiovascular disease.

A handy device to do a blood test that checks how well your kidneys are filtering your blood, called GFR from the comfort of home. GFR stands for glomerular filtration rate.

A handy device to do a urine test to check for albumin from the comfort of home. Albumin is a protein that can pass into the urine when the kidneys are damaged.

Category 4: Using data

Using medical history of patients immediate family and ancestors to predict the kidney disease and the severity.

By given medical historical data and diagnostic data of a patient. Machine learning and Data Discovery approach can help identify risk of CKD at initial stage.

We could use data interpretation techniques to find the success rate in curing the disease.

Category 5: Machine Learning

Using machine learning techniques to get accurate results.

By using the machine learning techniques like Ant Colony Optimization algorithm in CKD used to find the optimal paths in chronic kidney disease.

Advanced machine-learning algorithms and Deep Neural Networks were utilized in the process of feature selection and model building.

Machine learning is a powerful tool for understanding and diagnosing chronic kidney disease.

By using machine learning to analyze data which provide large information of CKD.

Machine learning can help us understand which factors are associated with an increased risk of CKD.

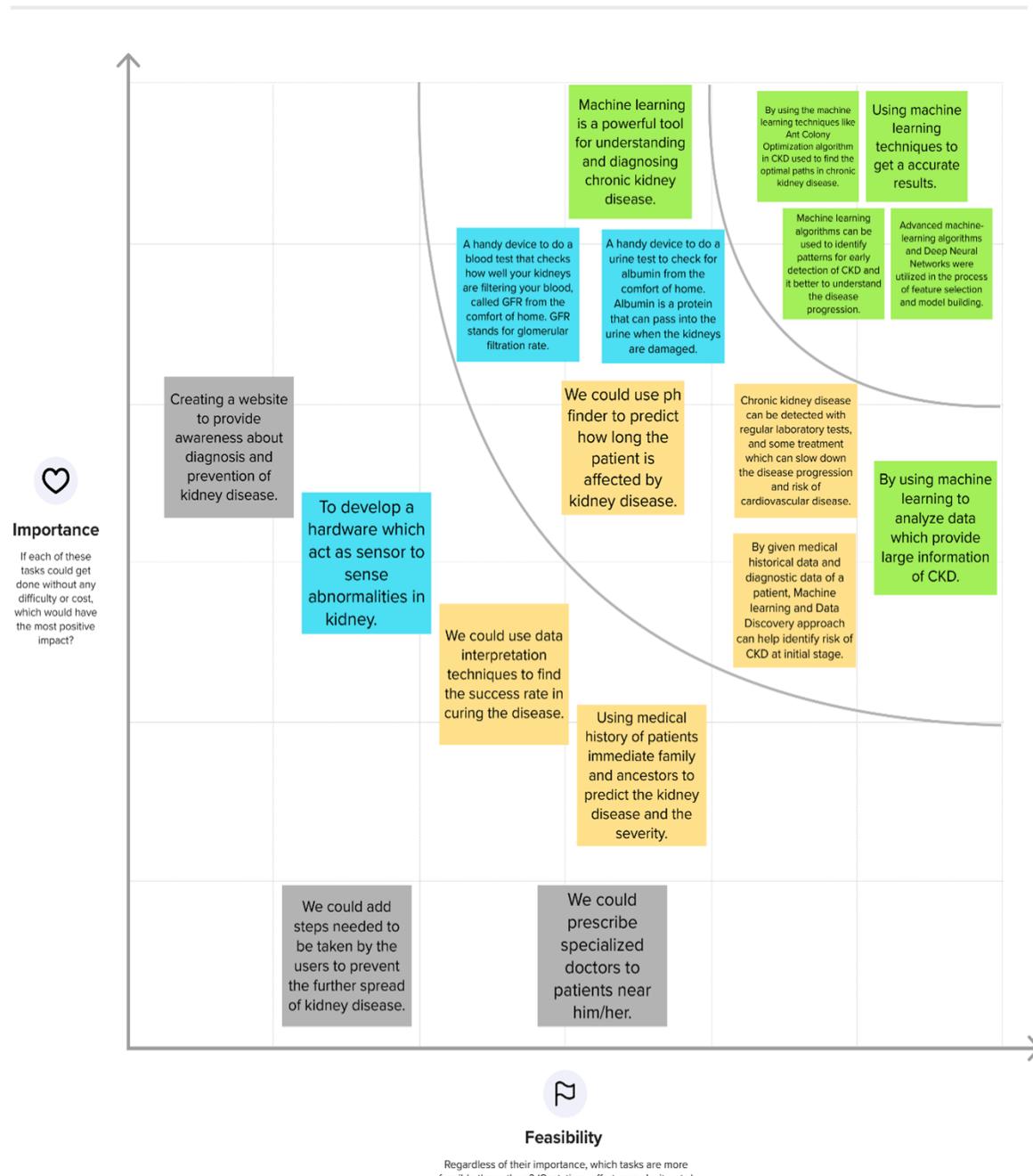
Machine learning algorithms can be used to identify patterns for early detection of CKD and it better to understand the disease progression.

4

Prioritize

Your team should all be on the same page about what's important moving forward. Place your ideas on this grid to determine which ideas are important and which are feasible.

⌚ 20 minutes



3.3 Proposed Solution:

The purpose of this tool is to provide a structured process for identifying a problem, understanding the root causes, ascertaining solution steps, and progress monitoring.

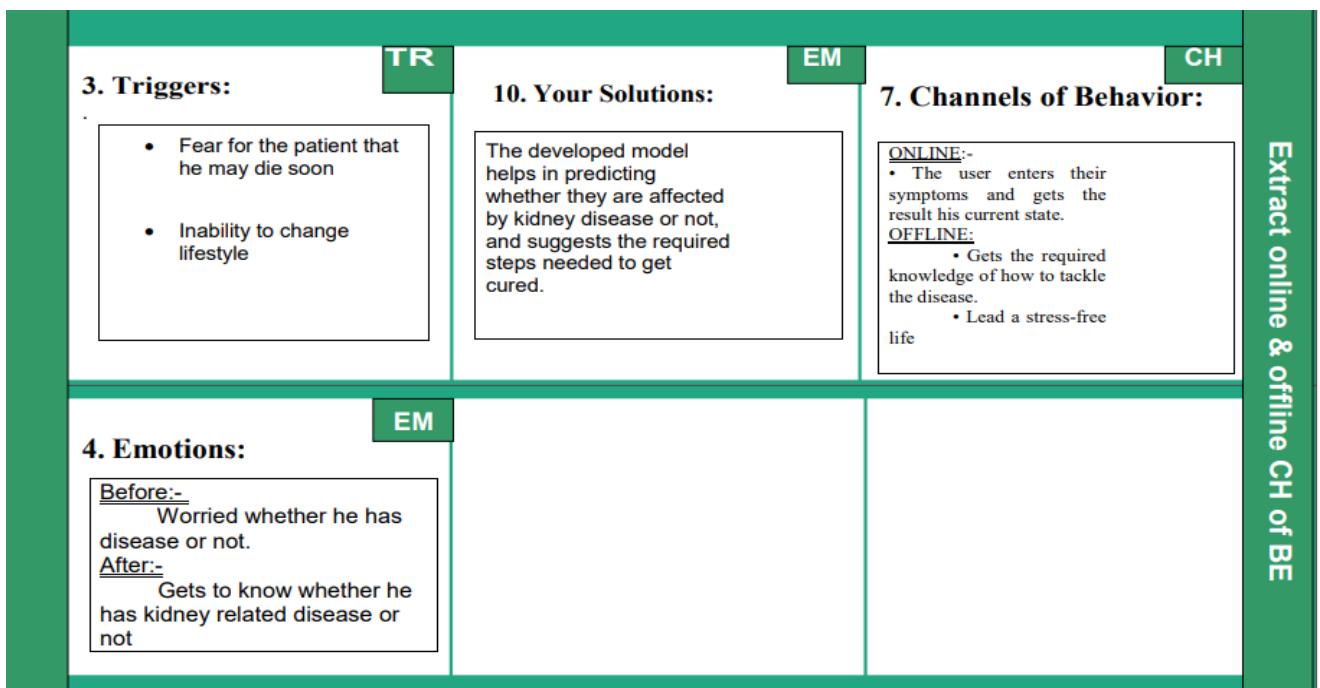
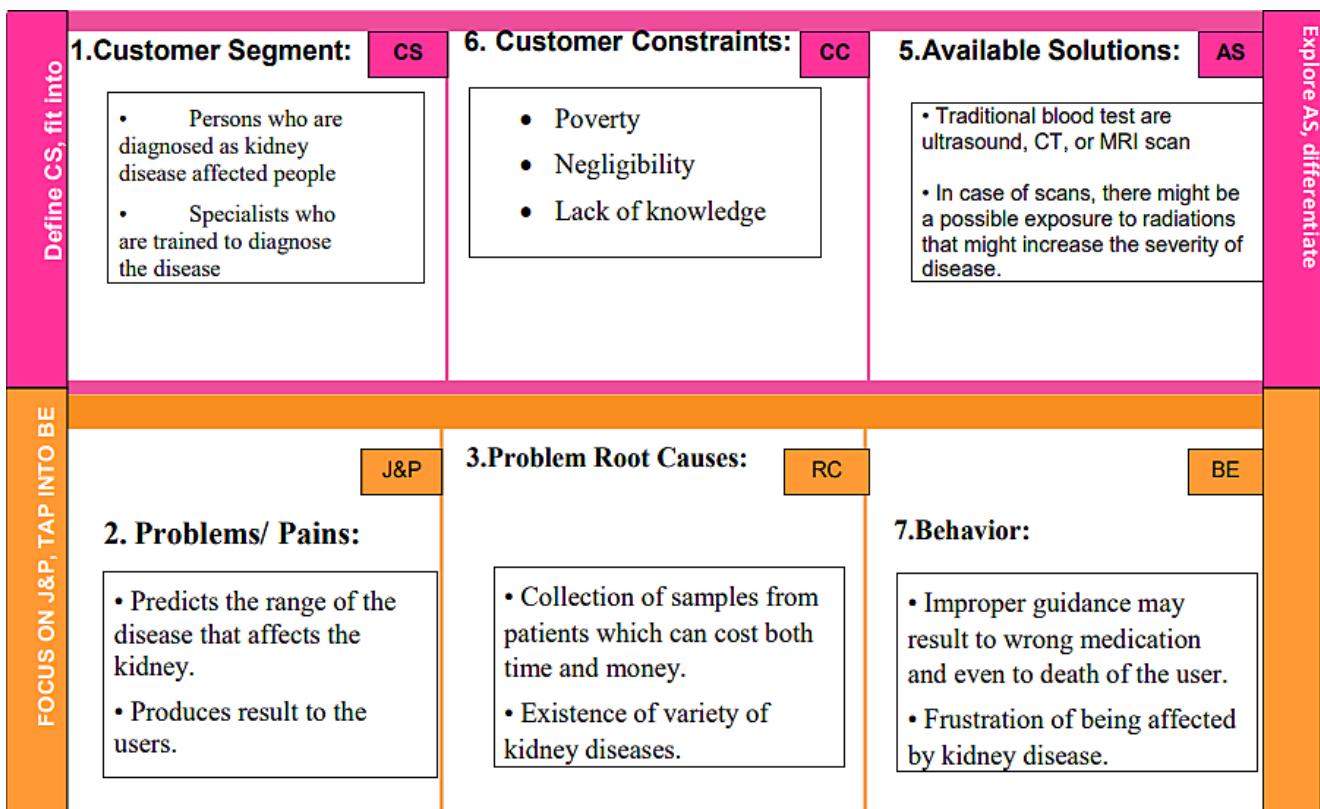
With a solution template, you can organize development content that you want to reuse for customer-specific solutions. Solution templates enable you to start the development of customer easily-specific solutions, for example, for a specific industry.

The term business model refers to a company's plan for making a profit. It identifies the products or services the business plans to sell, its identified target market, and any anticipated expenses. Business models are important for both new and established businesses.

S.no	Parameter	Description
1.	Problem Statement	Chronic Kidney Disease is a major concern for the global health care system. Chronic Kidney Disease is a wreaking havoc on society and is spreading at an alarming rate. Various efforts have been undertaken to advance early therapy to prevent the condition from progressing to CKD. Recent research suggests that some of the negative outcomes can be avoided with early identification and treatment.
2.	Feasibility of idea	To predict the early set of CKD, three Machine Learning techniques are used: <ul style="list-style-type: none"> • Random Forest, Decision Tree, SupportVector Machines.

		<ul style="list-style-type: none"> Using these techniques, each algorithm's effectiveness is evaluated and the prediction of how many people have been affected by CKD is identified.
3.	Novelty	<p>The renal patient is recognized by undertaking two primary tests.</p> <ul style="list-style-type: none"> A Blood Test to determine Glomerular Filtration Rate. A Urine Test to determine Albumin.
4.	Social Impact	<p>As people don't undergo the general test of their health, early detection of CKD is not identified. This creates a great social impact of not being aware of CKD. As a result of this many people are getting affected by CKD.</p>
5.	Business Model	<p>The widespread use of Machine Learning of predicting the CKD in the Medical Industries promotes medical innovation, lowers medical expenses, and improves medical quality. To cure the CKD patients, the hospitals have been gaining business profit in recovering the patients.</p>
6.	Scalability of solution	<p>ML Models can be modified and scaled easily and it will be easily accessible.</p>

3.4 Problem Solution fit:



4.0 REQUIREMENT ANALYSIS

4.1 Functional requirement:

Solution Requirements are identified before the technical solution is selected and/or designed. They describe the characteristics of a solution (functional and non-functional) that meet business requirements and stakeholder requirements.

A solution requirement is aimed at the concerns of the people who will build and deliver the solution. It tells those people what the functional and non-functional requirements for the solution will be and how the solution will deliver on the business and stakeholder requirements. Solution Requirements – Describe the features, functions, and characteristics of a product, service, or result that will meet the business and stakeholder requirements.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	In order to become a new user, you will need to register through a form
FR-2	User Login	Users who already have credentials can log in with those credentials
FR-3	User Requirements	Past records can be stored in a database Create a report to indicate whether or not there is chronic kidney disease present A diagnostic remedy for the symptoms that you are experiencing
FR-4	User Entry	A form to be filled out in order to enter the results of pre-diagnostic tests
FR-5	Business Requirements	Diagnose CKD quickly with a quick blood test
FR-6	User Feedback	The user can submit feedback through a form on the website

4.2 Non-Functional requirements:

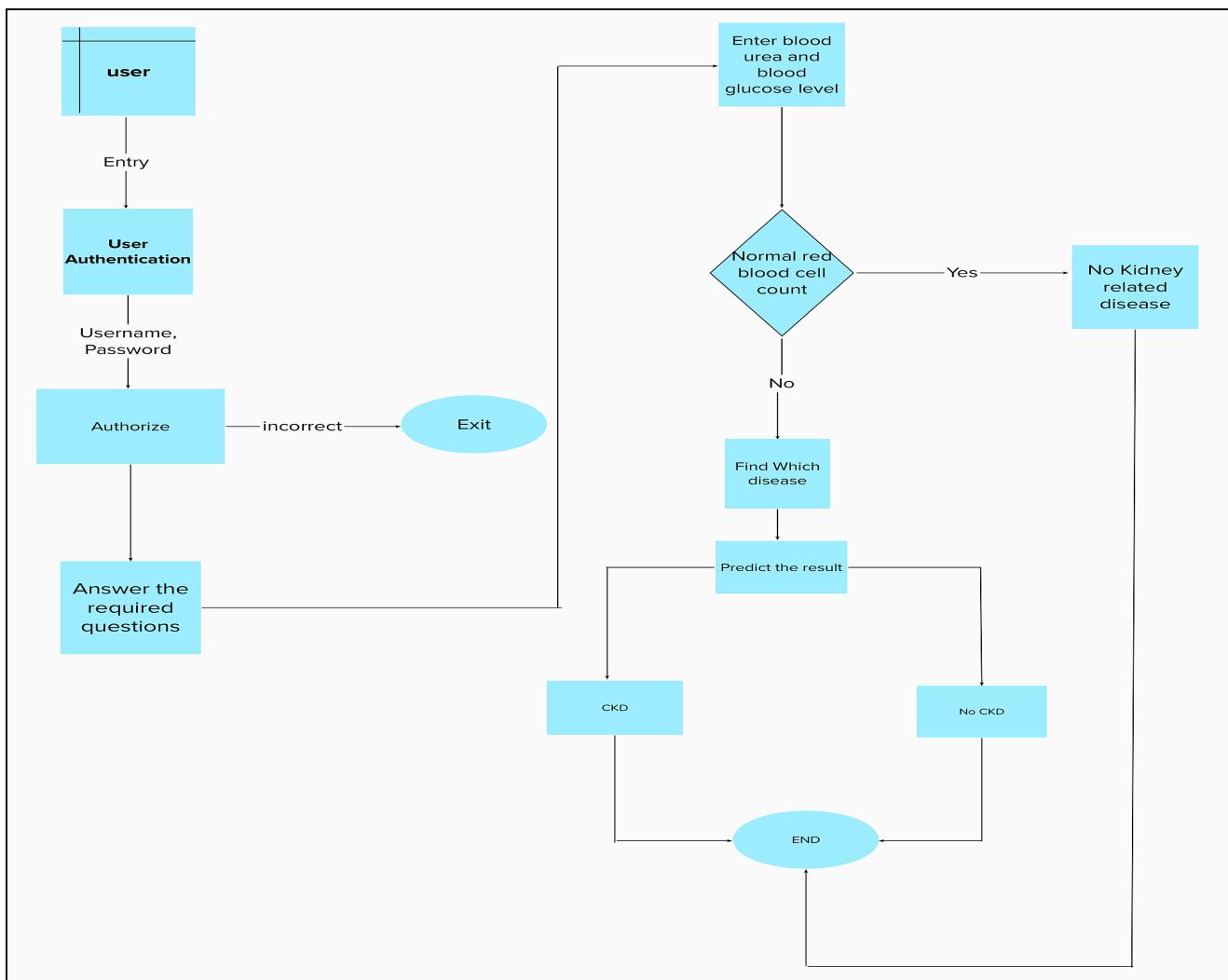
FR No.	Non-Functional Requirement	Description
NFR-1	Usability	Easy-to-use interface for communication that is user-friendly
NFR-2	Security	Maintain the confidentiality of the details that users share with you
NFR-3	Reliability	A ML model must be able to predict probabilities with sufficient accuracy to provide a reliable diagnosis
NFR-4	Performance	A reduction in the overall time it takes for a diagnosis to be completed
NFR-5	Availability	The service is available to users from various locations at any time
NFR-6	Scalability	A large number of users need to be supported at the same time

5.0 PROJECT DESIGN

5.1 Data Flow Diagrams:

A Data Flow Diagram (DFD) is a graphical representation of the “flow” of data through an information system(as shown on the DFD flow chart Figure 5), modeling its process aspects. Often it is a preliminary step used to create an overview of the system that can later be elaborated.

In software development and product management, a user story is an informal, natural language description of features of a software system. They are written from the perspective of an end user or user of a system, and may be recorded on index cards, Post-it notes, or digitally in project management software.

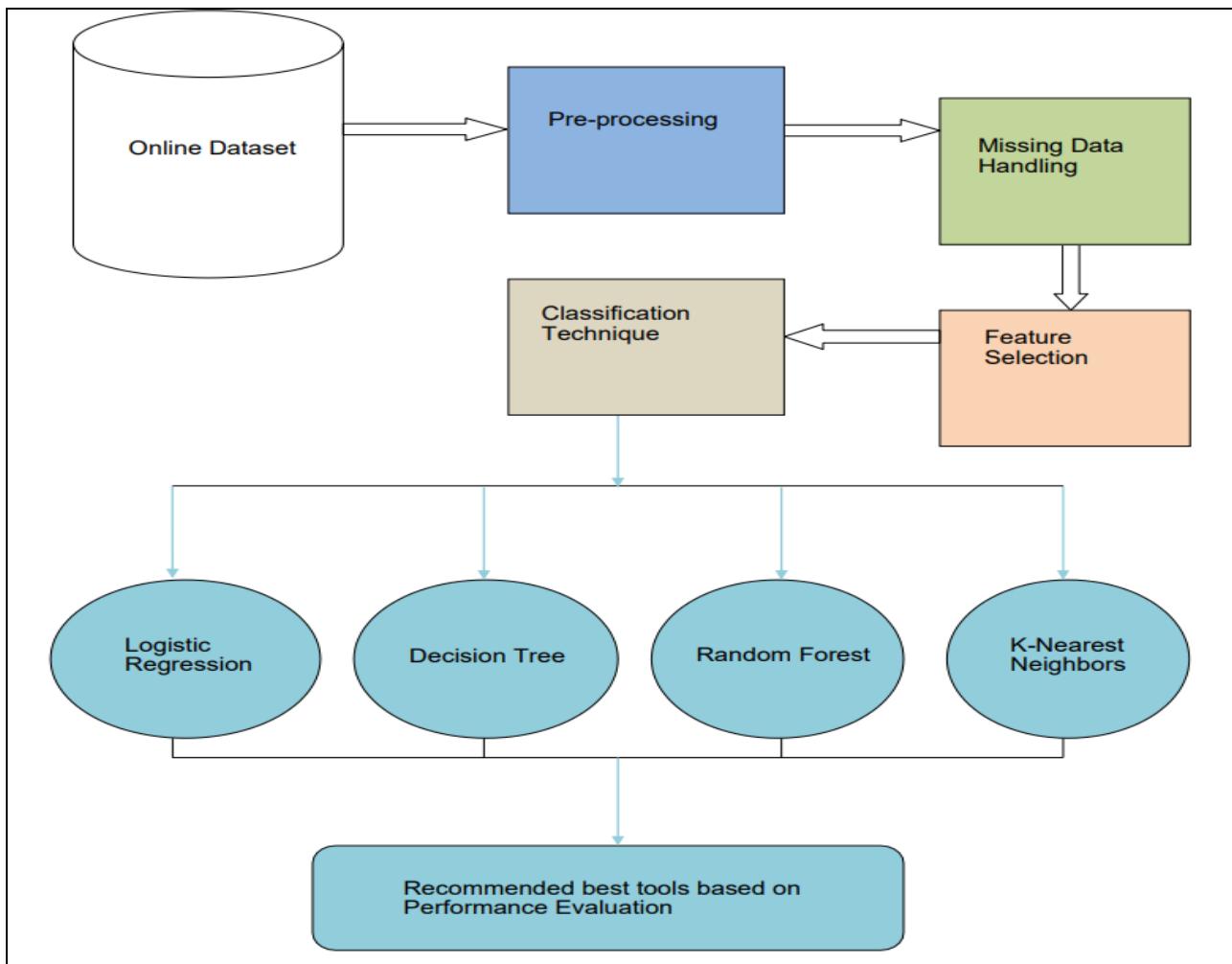


5.2 Solution & Technical Architecture:

A solutions architect creates the overall technical vision for a specific solution to a business problem. A solutions architect creates the overall technical vision for a specific solution to a business problem. They design, describe, and manage the solution.

Solution Architect: Processes, Role Description, Responsibilities, and Certifications

- Matching solutions with the corporate environment.
- Meeting the requirements of all stakeholders.
- Accounting for project constraints.
- Selecting the project technology stack.
- Compliance with non-functional requirements.



Technical Architecture:

Technology Architecture describes the logical software and hardware capabilities that are required to support the deployment of business, data, and application services. This includes IT infrastructure, middleware, networks, communications, processing, standards, etc.

Technology architecture deals with the deployment of application components on technology components. A standard set of predefined technology components is provided in order to represent servers, network, workstations.

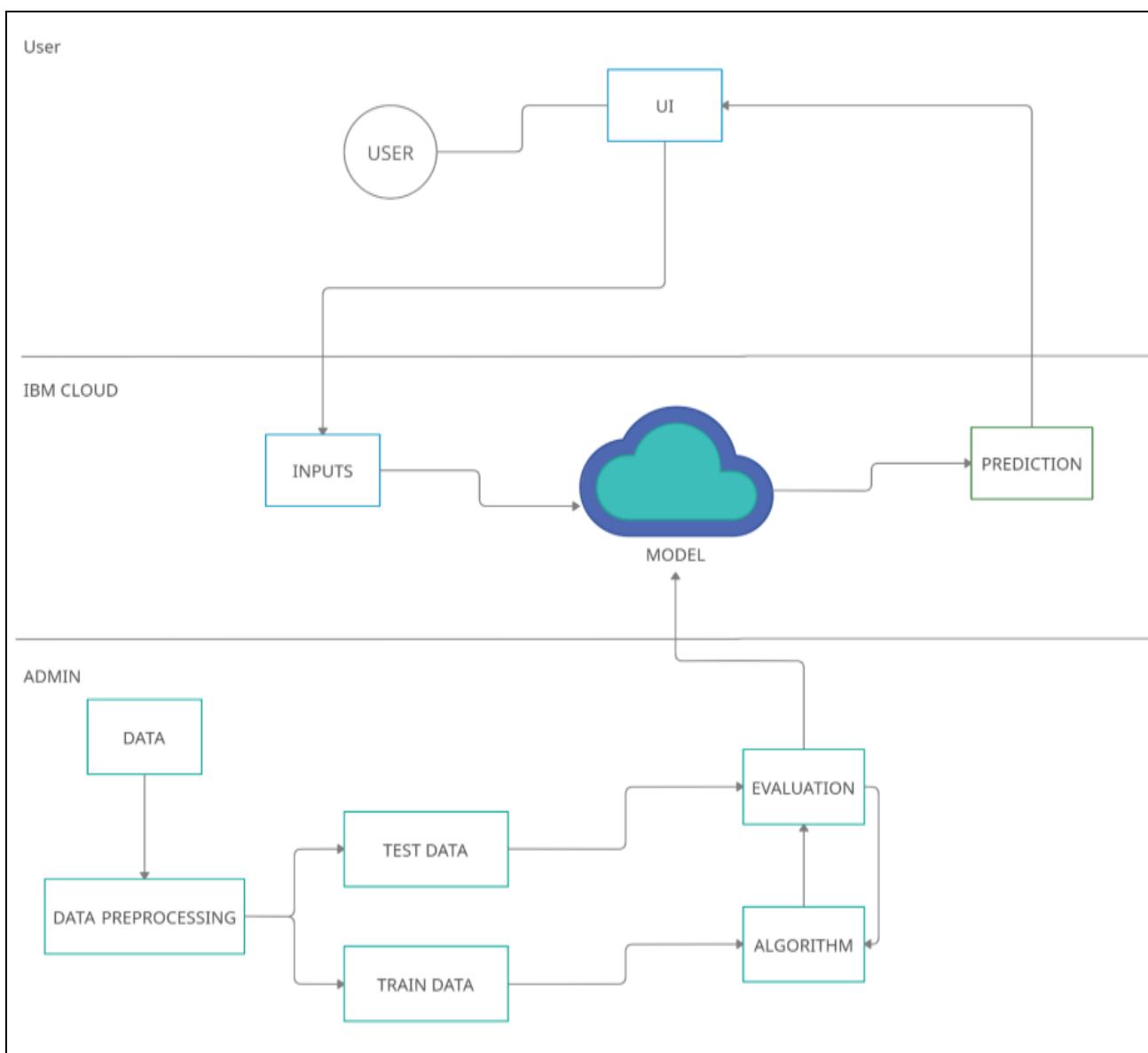


Table-1 : Components & Technologies:

S.No	Component	Description	Technology
1.	User Interface	How user interacts with application e.g. Web UI, Mobile App, Chatbot etc.	HTML, CSS, JavaScript / Angular Js / React Js etc.
2.	Application Logic-1	Logic for a process in the application	HTML, CSS, Python flask
3.	Application Logic-2	Logic for a process in the application	Machine Learning with Python
4.	Application Logic-3	Logic for a process in the application	HTML, CSS, Python flask
5.	Database	Data Type, Configurations etc.	MySQL, NoSQL, etc.
6.	Cloud Database	Database Service on Cloud	IBM DB2, IBM Cloudant etc.
7.	File Storage	File storage requirements	IBM Cloud Services
8.	External API-1	Purpose of External API used in the application	NIL
9.	External API-2	Purpose of External API used in the application	NIL
10.	Machine Learning Model	Purpose of Machine Learning Model	Random forest, Decision Tree, Support Vector Machine.
11.	Infrastructure (Server / Cloud)	Application Deployment on Local System / Cloud Local Server Configuration: Cloud Server Configuration :	IBM Cloud.

Table-2: Application Characteristics:

S.No	Characteristics	Description	Technology
1.	Open-Source Frameworks	List the open-source frameworks used	IBM Cloud, Python
2.	Security Implementations	List all the security / access controls implemented, use of firewalls etc.	Workload Protection, Identity and Access Protection
3.	Scalable Architecture	Justify the scalability of architecture (3 – tier, Micro-services)	Python
4.	Availability	Justify the availability of application (e.g. use of load balancers, distributed servers etc.)	IBM cloud
5.	Performance	Design consideration for the performance of the application (number of requests per sec, use of Cache, use of CDN's) etc.	Machine Learning Prediction and Classification techniques

5.3 User Stories:

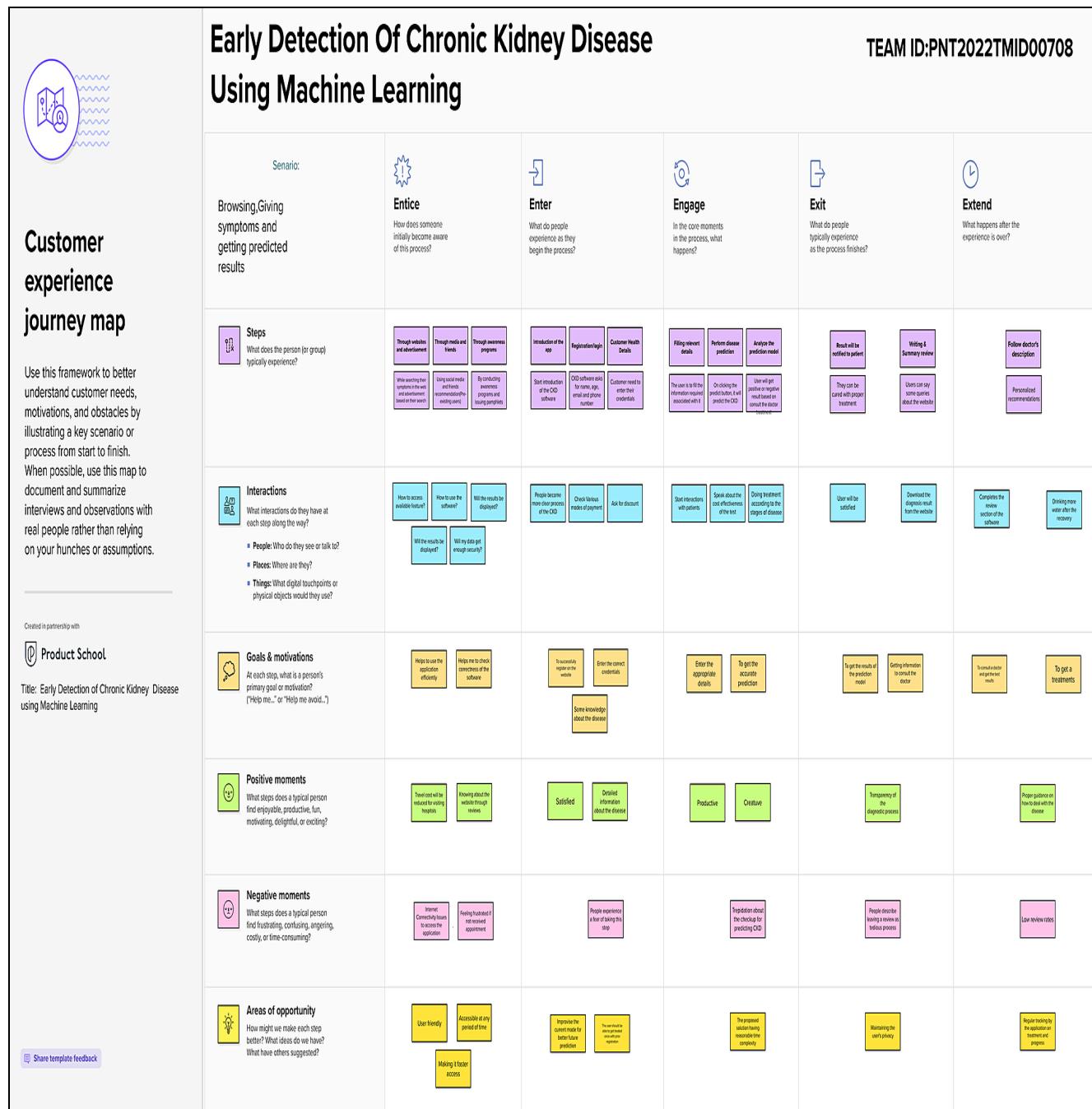
A user story is an informal, general explanation of a software feature written from the perspective of the end user. Its purpose is to articulate how a software feature will provide value to the customer.

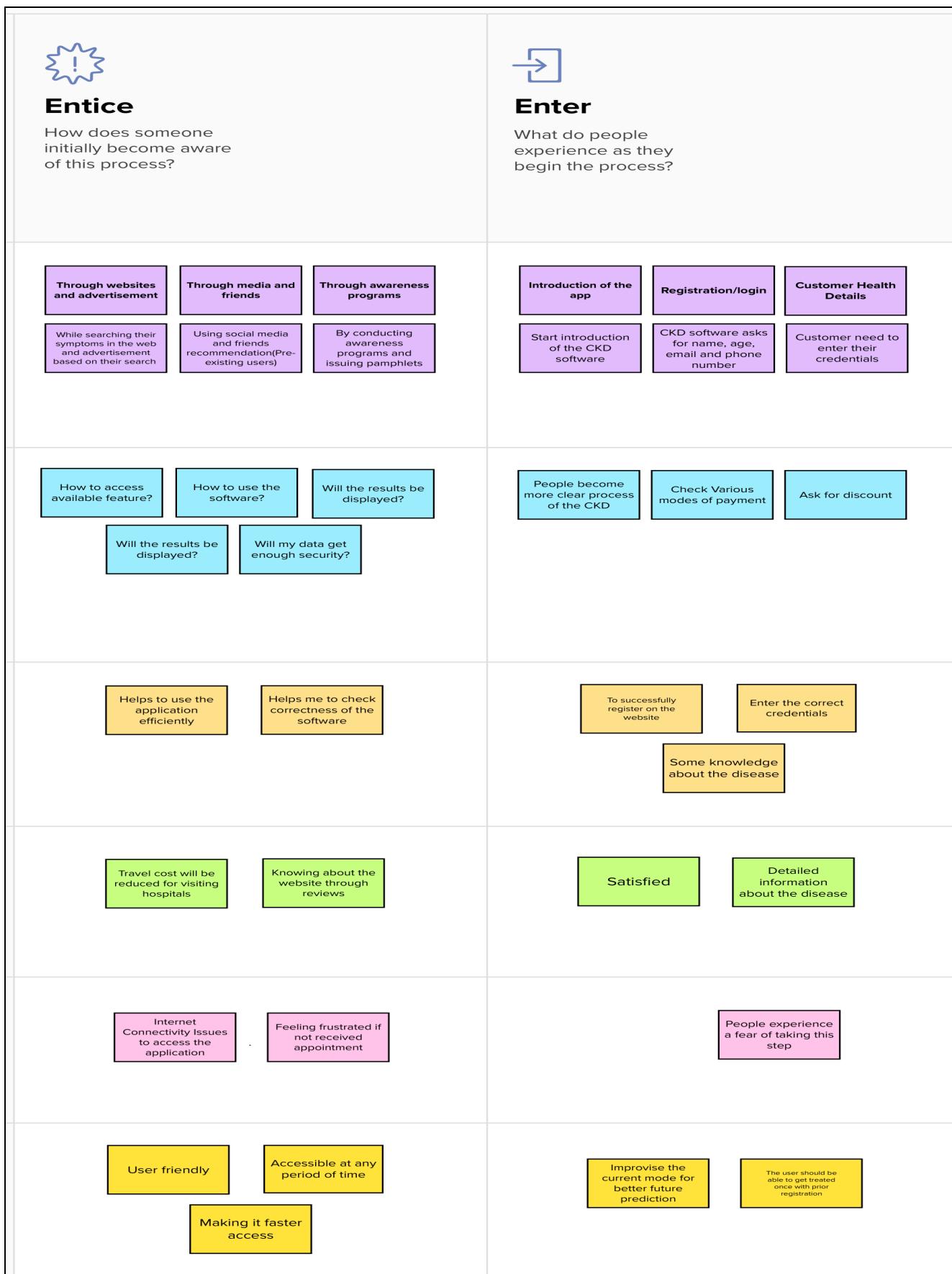
User stories are one of the core components of an agile program. They help provide a user-focused framework for daily work – which drives collaboration, creativity, and a better product overall.

User type	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members	Sprint
Developer	Collection of Dataset	USN-1	Collect dataset and clean the dataset	5	High	K PraveenKumar	Sprint-1
Developer		USN-2	Create, test and save the model	5	High	K PraveenKumar	Sprint-1
Customer	Home page	USN-3	The user can enter into the home page	6	High	N Sundareswar	Sprint-2
Customer		USN-4	User can use the prediction button to enter into the prediction page	4	Medium	S Sarath	Sprint-2
Customer Data Entry	Prediction page	USN-5	The user will be presented with the prediction page where he can enter the values of report	3	Medium	S Sarath	Sprint-3
Customer Data Entry		USN-6	User should enter the blood glucose parameters	7	High	Ramakrishna	Sprint-3
Customer Result Viewing	Result	USN-7	The user will get the output	4	Medium	K PraveenKumar	Sprint-4
Sprint-4		USN-8	Deploy into IBM CLOUD	6	High	N Sundareswar	Sprint-4

Customer Journey Map:

A customer journey map is a visual storyline of every engagement a customer has with a service, brand, or product. The creation of a journey map puts the organization directly in the mind of the consumer, so they can see and understand their customer's processes, needs, and perceptions.





 <h2>Engage</h2> <p>In the core moments in the process, what happens?</p>	 <h2>Exit</h2> <p>What do people typically experience as the process finishes?</p>
<div style="background-color: #e6f2ff; padding: 5px;"> Filling relevant details </div> <div style="background-color: #e6f2ff; padding: 5px;"> Perform disease prediction </div> <div style="background-color: #e6f2ff; padding: 5px;"> Analyze the prediction model </div> <div style="background-color: #e6f2ff; padding: 5px; margin-top: 10px;"> The user is to fill the information required associated with it </div> <div style="background-color: #e6f2ff; padding: 5px; margin-top: 10px;"> On clicking the predict button, it will predict the CKD </div> <div style="background-color: #e6f2ff; padding: 5px; margin-top: 10px;"> User will get positive or negative result based on consult the doctor treatment </div>	<div style="background-color: #e6f2ff; padding: 5px;"> Result will be notified to patient </div> <div style="background-color: #e6f2ff; padding: 5px; margin-top: 10px;"> They can be cured with proper treatment </div> <div style="background-color: #e6f2ff; padding: 5px; margin-top: 10px;"> Writing & Summary review </div> <div style="background-color: #e6f2ff; padding: 5px; margin-top: 10px;"> Users can say some queries about the website </div>
<div style="background-color: #e6f2ff; padding: 5px;"> Start interactions with patients </div> <div style="background-color: #e6f2ff; padding: 5px;"> Speak about the cost effectiveness of the test </div> <div style="background-color: #e6f2ff; padding: 5px;"> Doing treatment according to the stages of disease </div>	<div style="background-color: #e6f2ff; padding: 5px;"> User will be satisfied </div> <div style="background-color: #e6f2ff; padding: 5px; margin-top: 10px;"> Download the diagnosis result from the website </div>
<div style="background-color: #ffffcc; padding: 5px;"> Enter the appropriate details </div> <div style="background-color: #ffffcc; padding: 5px; margin-top: 10px;"> To get the accurate prediction </div>	<div style="background-color: #ffffcc; padding: 5px;"> To get the results of the prediction model </div> <div style="background-color: #ffffcc; padding: 5px; margin-top: 10px;"> Getting information to consult the doctor </div>
<div style="background-color: #e6ffe6; padding: 5px;"> Productive </div> <div style="background-color: #e6ffe6; padding: 5px; margin-top: 10px;"> Creative </div>	<div style="background-color: #e6ffe6; padding: 5px;"> Transparency of the diagnostic process </div> <div style="background-color: #e6ffe6; padding: 5px; margin-top: 10px;"> Trepidation about the checkup for predicting CKD </div> <div style="background-color: #e6ffe6; padding: 5px; margin-top: 10px;"> People describe leaving a review as tedious process </div>

 <h3>Exit</h3> <p>What do people typically experience as the process finishes?</p>	 <h3>Extend</h3> <p>What happens after the experience is over?</p>
<div style="background-color: #e6f2ff; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Result will be notified to patient</div> <div style="background-color: #e6f2ff; padding: 5px; border: 1px solid black; margin-bottom: 5px;">They can be cured with proper treatment</div>	<div style="background-color: #e6f2ff; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Writing & Summary review</div> <div style="background-color: #e6f2ff; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Users can say some queries about the website</div> <div style="background-color: #e6f2ff; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Follow doctor's description</div> <div style="background-color: #e6f2ff; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Personalized recommendations</div>
<div style="background-color: #e6f2ff; padding: 5px; border: 1px solid black; margin-bottom: 5px;">User will be satisfied</div> <div style="background-color: #e6f2ff; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Download the diagnosis result from the website</div>	<div style="background-color: #e6f2ff; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Completes the review section of the software</div> <div style="background-color: #e6f2ff; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Drinking more water after the recovery</div>
<div style="background-color: #ffffcc; padding: 5px; border: 1px solid black; margin-bottom: 5px;">To get the results of the prediction model</div> <div style="background-color: #ffffcc; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Getting information to consult the doctor</div>	<div style="background-color: #ffffcc; padding: 5px; border: 1px solid black; margin-bottom: 5px;">To consult a doctor and get the test results</div> <div style="background-color: #ffffcc; padding: 5px; border: 1px solid black; margin-bottom: 5px;">To get a treatments</div>
<div style="background-color: #90EE90; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Transparency of the diagnostic process</div>	<div style="background-color: #90EE90; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Proper guidance on how to deal with the disease</div>
<div style="background-color: #ffcccc; padding: 5px; border: 1px solid black; margin-bottom: 5px;">People describe leaving a review as tedious process</div>	<div style="background-color: #ffcccc; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Low review rates</div>
<div style="background-color: #ffffcc; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Maintaining the user's privacy</div>	<div style="background-color: #ffffcc; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Regular tracking by the application on treatment and progress</div>

6. PROJECT PLANNING & SCHEDULING

6.1 Sprint Planning & Estimation:

A project plan template is a document that creates a standard format for a project plan. Typically, it contains a list of the essential elements of a project, such as stakeholders, scope, timelines, estimated cost and communication methods. The project manager typically lists the information based on the assignment.

Product Backlog, Sprint Schedule, and Estimation :

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Collection of Dataset	USN-1	Collect dataset and clean the dataset	5	High	K PraveenKumar
Sprint-1		USN-2	Create, test and save the model	5	High	K PraveenKumar
Sprint-2	Home page	USN-3	The user can enter into the home page	6	High	N Sundareswar
Sprint-2		USN-4	User can use the prediction button to enter into the prediction page	4	Medium	S Sarath
Sprint-3	Prediction page	USN-5	The user will be presented with the prediction page where he can enter the values of report	3	Medium	S Sarath
Sprint-3		USN-6	User should enter the blood glucose parameters	7	High	Ramakrishna
Sprint-4	Result	USN-7	The user will get the output	4	Medium	K PraveenKumar
Sprint-4		USN-8	Deploy into IBM CLOUD	6	High	N Sundareswar

Project Tracker, Velocity & Burndown Chart :

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	10	6 Days	24 Oct 2022	29 Oct 2022	10	29 Oct 2022
Sprint-2	10	6 Days	31 Oct 2022	05 Nov 2022	10	31 Oct 2022
Sprint-3	10	6 Days	07 Nov 2022	12 Nov 2022	10	07 Nov 2022
Sprint-4	10	6 Days	14 Nov 2022	19 Nov 2022	10	14 Nov 2022

6.2 Sprint Delivery Schedule:

A milestone list is a project management document that identifies all project milestones. A milestone is a significant event or a point in a project. It represents nothing more than a moment in time; hence, when scheduling, milestones should be assigned zero duration.

A milestone is a specific point within a project's life cycle used to measure the progress toward the ultimate goal. Milestones in project management are used as signal posts for a project's start or end date, external reviews or input, budget checks, submission of a major deliverable, etc.

Milestone is a point on the schedule, which has one clearly defined deliverable, whereas a task is an activity that should be completed to achieve a milestone. An activity / task has a start and end date. It's two dimensional, whereas a milestone is a single date upon which a deliverable gets completed.

TITLE	DESCRIPTION	DATE
Literature Survey & Information-gathering	Literature survey on the project & gathering information by referring technical papers, research publications, journals.	26 SEPTEMBER 2022
Prepare Empathy Map	Prepare Empathy Map Canvas to capture the user Pains & Gains. Prepare list of problem Statements that are to be solved by this project.	26 SEPTEMBER 2022
Ideation	List the ideas by organizing a brainstorming session and prioritize the top 3 ideas based on the feasibility & importance.	26 SEPTEMBER 2022
Proposed Solution	Prepare the proposed solution document, which includes novelty, feasibility of idea, revenue model, social impact, scalability of solution.	03 OCTOBER 2022
Problem Solution Fit	Prepare problem - solution fit document.	03 OCTOBER 2022

Solution Architecture	Prepare solution architecture document.	03 OCTOBER 2022
Customer Journey	Prepare the customer journey maps to understand the user interactions & experiences with the application.	14 OCTOBER 2022
Data Flow Diagrams	Draw the data flow diagrams.	14 OCTOBER 2022
Technology Architecture	Prepare the technology architecture diagram.	13 OCTOBER 2022
Prepare Milestone & Activity List	Prepare the milestones & activity list of the project.	29 OCTOBER 2022
Project Development - Delivery of Sprint-1, 2, 3 & 4	Develop & submit the developed code by testing it.	IN PROGRESS

6.3 Reports from JIRA:

Sprint planning is an event in scrum that kicks off the sprint. The purpose of sprint planning is to define what can be delivered in the sprint and how that work will be achieved. Sprint planning is done in collaboration with the whole scrum team.

The 3 Essential Phases of Planning Successful Sprints

- Phase One: Designing.
- Phase Two: Estimate Sprint Velocity.
- Phase Three: Allocate Work to the Sprint.

▼ EDCKDUML Sprint 1 24 Oct – 29 Oct (2 issues)

- EDCKDUML-2 Collect dataset from Google and clean the dataset [DATASET](#)

- EDCKDUML-3 Create, test and save the model [DATASET](#)

+ Create issue

▼ EDCKDUML Sprint 2 31 Oct – 5 Nov (2 issues)

- EDCKDUML-4 The user can enter into the home page [HOME PAGE](#)

- EDCKDUML-5 User can use the prediction button to enter into the prediction page [HOME PAGE](#)

+ Create issue

▼ EDCKDUML Sprint 3 7 Nov – 12 Nov (2 issues)

- EDCKDUML-6 The user will be presented with the prediction page where he can enter the values of report [PREDICTION PAGE](#)

- EDCKDUML-7 User should enter the blood glucose parameters [PREDICTION PAGE](#)

+ Create issue

▼ EDCKDUML Sprint 4 14 Nov – 19 Nov (2 issues)

- EDCKDUML-8 The user will get the output [RESULT](#)

- EDCKDUML-9 Deploy into IBM CLOUD [RESULT](#)

Sprint - 1:

[EDCKDUML-1] Collect dataset from Google and clean the dataset Created: 01/Nov/22 Updated: 17/Nov/22			
Status:	To Do		
Project:	Early Detection of Chronic Kidney Disease using Machine Learning		
Components:	None		
Affects versions:	None		
Fix versions:	None		
Type:	Story	Priority:	Medium
Reporter:	Praveen Kumar	Assignee:	Praveen Kumar
Resolution:	Unresolved	Votes:	0
Labels:	None		
Remaining Estimate:	Not Specified		
Time Spent:	Not Specified		
Original estimate:	Not Specified		
Rank:	0 hzzzzj:		
Story point estimate:	5		
Sprint:	EDCKDUML Sprint 1, EDCKDUML Sprint 1		
[EDCKDUML-2] Create, test and save the model Created: 01/Oct/22 Updated: 17/Nov/22			
Status:	To Do		
Project:	Early Detection of Chronic Kidney Disease using Machine Learning		
Components:	None		
Affects versions:	None		
Fix versions:	None		
Type:	Story	Priority:	Medium
Reporter:	Praveen Kumar	Assignee:	Praveen Kumar
Resolution:	Unresolved	Votes:	0
Labels:	None		
Remaining Estimate:	Not Specified		
Time Spent:	Not Specified		
Original estimate:	Not Specified		
Rank:	0 hzzzzr:		
Story point estimate:	5		
Sprint:	EDCKDUML Sprint 1, EDCKDUML Sprint 1		

Sprint - 2:

[EDCKDUML-3] The user can enter into the home page		Created: 01/Oct/22 Updated: 17/Nov/22
Status: To Do		
Project: Early Detection of Chronic Kidney Disease using Machine Learning		
Components: None		
Affects versions: None		
Fix versions: None		
Type: Story	Priority: Medium	
Reporter: Praveen Kumar	Assignee: gokussb46	
Resolution: Unresolved	Votes: 0	
Labels: None		
Remaining Estimate: Not Specified		
Time Spent: Not Specified		
Original estimate: Not Specified		
Rank: 0 i0000f:		
Story point estimate: 6		
Sprint: EDCKDUML Sprint 2, EDCKDUML Sprint 2		
[EDCKDUML-4] User can use the prediction button to enter into the prediction page		Created: 01/Oct/22 Updated: 17/Nov/22
Status: To Do		
Project: Early Detection of Chronic Kidney Disease using Machine Learning		
Components: None		
Affects versions: None		
Fix versions: None		
Type: Story	Priority: Medium	
Reporter: Praveen Kumar	Assignee: s.sarathsubburaj	
Resolution: Unresolved	Votes: 0	
Labels: None		
Remaining Estimate: Not Specified		
Time Spent: Not Specified		
Original estimate: Not Specified		
Rank: 0 i0000n:		
Story point estimate: 4		
Sprint: EDCKDUML Sprint 2, EDCKDUML Sprint 2		

Sprint - 3:

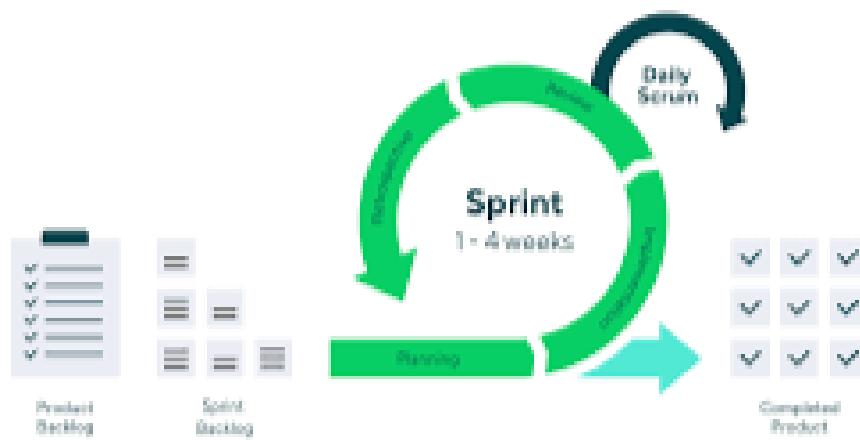
[EDCKDUML-6] The user will be presented with the prediction page where he can enter the values of report		Created: 01/Nov/22 Updated: 17/Nov/22
Status:	To Do	
Project:	Early Detection of Chronic Kidney Disease using Machine Learning	
Components:	None	
Affects versions:	None	
Fix versions:	None	
Type:	Story	Priority: Medium
Reporter:	Praveen Kumar	Assignee: s.sarathsubburaj
Resolution:	Unresolved	Votes: 0
Labels:	None	
Remaining Estimate:	Not Specified	
Time Spent:	Not Specified	
Original estimate:	Not Specified	
Rank:	0 i0000v:	
Story point estimate:	3	
Sprint:	EDCKDUML Sprint 3	
[EDCKDUML-6] User should enter the blood glucose parameters		Created: 01/Oct/22 Updated: 17/Nov/22
Status:	To Do	
Project:	Early Detection of Chronic Kidney Disease using Machine Learning	
Components:	None	
Affects versions:	None	
Fix versions:	None	
Type:	Story	Priority: Medium
Reporter:	Praveen Kumar	Assignee: ramakrishnaputtagunta0
Resolution:	Unresolved	Votes: 0
Labels:	None	
Remaining Estimate:	Not Specified	
Time Spent:	Not Specified	
Original estimate:	Not Specified	
Rank:	0 i00013:	
Story point estimate:	7	
Sprint:	EDCKDUML Sprint 3	

Sprint - 4:

[EDCKDUML-7] The user will get the output		Created: 01/Oct/22 Updated: 17/Nov/22
Status:	To Do	
Project:	Early Detection of Chronic Kidney Disease using Machine Learning	
Components:	None	
Affects versions:	None	
Fix versions:	None	
Type:	Story	Priority: Medium
Reporter:	Praveen Kumar	Assignee: Praveen Kumar
Resolution:	Unresolved	Votes: 0
Labels:	None	
Remaining Estimate:	Not Specified	
Time Spent:	Not Specified	
Original estimate:	Not Specified	
Rank:	0 i0001b:	
Story point estimate:	4	
Sprint:	EDCKDUML Sprint 4	
[EDCKDUML-8] Deploy into IBM CLOUD		Created: 01/Oct/22 Updated: 17/Nov/22
Status:	To Do	
Project:	Early Detection of Chronic Kidney Disease using Machine Learning	
Components:	None	
Affects versions:	None	
Fix versions:	None	
Type:	Story	Priority: Medium
Reporter:	Praveen Kumar	Assignee: gokussb46
Resolution:	Unresolved	Votes: 0
Labels:	None	
Remaining Estimate:	Not Specified	
Time Spent:	Not Specified	
Original estimate:	Not Specified	
Rank:	0 i0001j:	
Story point estimate:	6	
Sprint:	EDCKDUML Sprint 4	

7. CODING & SOLUTIONING

During the Project Development Phase we have done four Sprints they are Sprint 1, Sprint 2, Sprint 3 and Sprint 4. In Agile product development, a sprint is a set period of time during which specific work has to be completed and made ready for review. Each sprint begins with a planning meeting. During the meeting, the product owner (the person requesting the work) and the development team agree upon exactly what work will be accomplished during the sprint. The development team has the final say when it comes to determining how much work can realistically be accomplished during the sprint, and the product owner has the final say on what criteria need to be met for the work to be approved and accepted. The duration of a sprint is determined by the scrum master, the team's facilitator and manager of the Scrum framework. Once the team reaches a consensus for how many days a sprint should last, all future sprints should be the same. Traditionally, a sprint lasts 30 days. After a sprint begins, the product owner must step back and let the team do their work. During the sprint, the team holds daily stand-up meetings to discuss progress and brainstorm solutions to challenges. The project owner may attend these meetings as an observer but is not allowed to participate unless it is to answer questions. (See pigs and chickens). The project owner may not make requests for changes during a sprint and only the scrum master or project manager has the power to interrupt or stop the sprint. At the end of the sprint, the team presents its completed work to the project owner and the project owner uses the criteria established at the sprint planning meeting to either accept or reject the work.



7.1 Feature 1:

During Sprint1 we have planned for Downloading the dataset, import the libraries, Read the dataset, Understanding data types and summary of features, Handling missing values, Replacing the missing values, Label encoding.

```
In [1]: # necessary imports
from matplotlib import pyplot as plt
import pandas as pd
import numpy as np
import seaborn as sns
import plotly.express as px

import warnings
warnings.filterwarnings('ignore')

plt.style.use('fivethirtyeight')
%matplotlib inline
pd.set_option('display.max_columns', 26)

In [2]: # Loading data
df= pd.read_csv(r'C:\Users\SUNDARESWAR\Downloads>New folder\Dataset-20221119T072328Z-001\Dataset\chronickidneydisease.csv')
df.head()

Out[2]:
   id  age  bp    sg    al    su   rbc      pc     pcc      ba    bgr    bu    sc    sod    pot   hemo    pcv    wc    rc    htn    dm    cad    appet    pe    ane
0   0  48.0  80.0  1.020  1.0  0.0    NaN  normal  notpresent  121.0  36.0  1.2  NaN  NaN  15.4  44  7800  5.2  yes  yes  no  good  no  no
1   1   7.0  50.0  1.020  4.0  0.0    NaN  normal  notpresent  NaN  18.0  0.8  NaN  NaN  11.3  38  6000  NaN  no  no  no  good  no  no
2   2  62.0  80.0  1.010  2.0  3.0  normal  normal  notpresent  423.0  53.0  1.8  NaN  NaN  9.6  31  7500  NaN  no  yes  no  poor  no  yes
3   3  48.0  70.0  1.005  4.0  0.0  normal  abnormal  present  notpresent  117.0  56.0  3.8  111.0  2.5  11.2  32  6700  3.9  yes  no  no  poor  yes  yes
4   4  51.0  80.0  1.010  2.0  0.0  normal  normal  notpresent  106.0  26.0  1.4  NaN  NaN  11.6  35  7300  4.6  no  no  no  good  no  no
```

```
In [3]: df.shape
Out[3]: (400, 26)

In [4]: # dropping id column
df.drop('id', axis = 1, inplace = True)

In [5]: # rename column names to make it more user-friendly
df.columns = ['age', 'blood_pressure', 'specific_gravity', 'albumin', 'sugar', 'red_blood_cells', 'pus_cell',
'pus_cell_clumps', 'bacteria', 'blood_glucose_random', 'blood_urea', 'serum_creatinine', 'sodium',
'potassium', 'haemoglobin', 'packed_cell_volume', 'white_blood_cell_count', 'red_blood_cell_count',
'hypertension', 'diabetes_mellitus', 'coronary_artery_disease', 'appetite', 'pedal_edema',
'aanemia', 'class']

In [6]: df.head()

Out[6]:
   age  blood_pressure  specific_gravity  albumin  sugar  red_blood_cells  pus_cell  pus_cell_clumps  bacteria  blood_glucose_random  blood_urea  serum_cr
0   48.0          80.0            1.020     1.0  0.0        NaN  normal  notpresent  notpresent  121.0           36.0
1    7.0          50.0            1.020     4.0  0.0        NaN  normal  notpresent  notpresent  NaN           18.0
2   62.0          80.0            1.010     2.0  3.0       normal  normal  notpresent  notpresent  423.0           53.0
3   48.0          70.0            1.005     4.0  0.0      normal  abnormal  present  notpresent  117.0           56.0
4   51.0          80.0            1.010     2.0  0.0       normal  normal  notpresent  notpresent  106.0           26.0
```

```
In [7]: df.describe()
Out[7]:
   age  blood_pressure  specific_gravity  albumin  sugar  blood_glucose_random  blood_urea  serum_creatinine  sodium  potassium  hae
count  391.000000    388.000000    353.000000    354.000000    351.000000    356.000000    381.000000    383.000000    313.000000    312.000000    34
mean   51.483376    76.469072    1.017408    1.016949    0.450142    148.036517    57.425722    3.072454    137.528754    4.627244    1
std    17.169714    13.683637    0.005717    1.352679    1.099191    79.281714    50.603006    5.741126    10.408752    3.193904
min    2.000000    50.000000    1.005000    0.000000    0.000000    22.000000    1.500000    0.400000    4.500000    2.500000
25%   42.000000    70.000000    1.010000    0.000000    0.000000    99.000000    27.000000    0.900000    135.000000    3.800000    1
50%   55.000000    80.000000    1.020000    0.000000    0.000000    121.000000    42.000000    1.300000    138.000000    4.400000    1
75%   64.500000    80.000000    1.020000    2.000000    0.000000    163.000000    66.000000    2.800000    142.000000    4.900000    1
max   90.000000    180.000000   1.025000    5.000000    5.000000    490.000000    391.000000    76.000000    163.000000    47.000000    1

In [8]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 400 entries, 0 to 399
Data columns (total 25 columns):
 #   Column          Non-Null Count  Dtype  
--- 
 0   age             391 non-null    float64
 1   blood_pressure  388 non-null    float64
 2   specific_gravity  353 non-null    float64
 3   albumin         354 non-null    float64
 4   sugar            351 non-null    float64
 5   red_blood_cells 248 non-null    object  
 6   pus_cell         335 non-null    object  
 7   pus_cell_clumps 396 non-null    object  
 8   bacteria         396 non-null    object  
 9   blood_glucose_random  356 non-null    float64
 10  blood_urea       381 non-null    float64
 11  serum_creatinine 383 non-null    float64
 12  sodium           313 non-null    float64
 13  potassium        312 non-null    float64
 14  haemoglobin     348 non-null    float64
 15  packed_cell_volume 330 non-null    object  
 16  white_blood_cell_count 295 non-null    object  
 17  red_blood_cell_count 270 non-null    object  
 18  hypertension      398 non-null    object  
 19  diabetes_mellitus 398 non-null    object  
 20  coronary_artery_disease 398 non-null    object  
 21  appetite          399 non-null    object  
 22  peda_edema        399 non-null    object  
 23  anemia            399 non-null    object  
 24  class             400 non-null    object  
dtypes: float64(11), object(14)
memory usage: 78.2+ KB
```

```
In [9]: # converting necessary columns to numerical type
df['packed_cell_volume'] = pd.to_numeric(df['packed_cell_volume'], errors='coerce')
df['white_blood_cell_count'] = pd.to_numeric(df['white_blood_cell_count'], errors='coerce')
df['red_blood_cell_count'] = pd.to_numeric(df['red_blood_cell_count'], errors='coerce')

In [10]: df.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 400 entries, 0 to 399
Data columns (total 25 columns):
 #   Column          Non-Null Count  Dtype  
--- 
 0   age             391 non-null    float64
 1   blood_pressure  388 non-null    float64
 2   specific_gravity  353 non-null    float64
 3   albumin         354 non-null    float64
 4   sugar            351 non-null    float64
 5   red_blood_cells 248 non-null    object  
 6   pus_cell         335 non-null    object  
 7   pus_cell_clumps 396 non-null    object  
 8   bacteria         396 non-null    object  
 9   blood_glucose_random  356 non-null    float64
 10  blood_urea       381 non-null    float64
 11  serum_creatinine 383 non-null    float64
 12  sodium           313 non-null    float64
 13  potassium        312 non-null    float64
 14  haemoglobin     348 non-null    float64
 15  packed_cell_volume 329 non-null    float64
 16  white_blood_cell_count 294 non-null    float64
 17  red_blood_cell_count 269 non-null    float64
 18  hypertension      398 non-null    object  
 19  diabetes_mellitus 398 non-null    object  
 20  coronary_artery_disease 398 non-null    object  
 21  appetite          399 non-null    object  
 22  peda_edema        399 non-null    object  
 23  anemia            399 non-null    object  
 24  class             400 non-null    object  
dtypes: float64(14), object(11)
memory usage: 78.2+ KB

In [11]: # Extracting categorical and numerical columns
cat_cols = [col for col in df.columns if df[col].dtype == 'object']
num_cols = [col for col in df.columns if df[col].dtype != 'object']
```

```
In [12]: # Looking at unique values in categorical columns
for col in cat_cols:
    print(f"{col} has {df[col].unique()} values\n")
red_blood_cells has [nan 'normal' 'abnormal'] values
pus_cell has ['normal' 'abnormal' nan] values
pus_cell_clumps has ['notpresent' 'present' nan] values
bacteria has ['notpresent' 'present' nan] values
hypertension has ['yes' 'no' nan] values
diabetes_mellitus has ['yes' 'no' 'yes' '\tno' '\tyes' nan] values
coronary_artery_disease has ['no' 'yes' '\tno' nan] values
appetite has ['good' 'poor' nan] values
peda_edema has ['no' 'yes' nan] values
aanemia has ['no' 'yes' nan] values
class has ['ckd' 'ckd\t' 'notckd'] values
```

Removing Ambiguity

```
In [13]: # replace incorrect values
df['diabetes_mellitus'].replace(to_replace = {'\tno':'no', '\tyes':'yes', ' yes':'yes'}, inplace=True)
df['coronary_artery_disease'] = df['coronary_artery_disease'].replace(to_replace = '\tno', value='no')
df['class'] = df['class'].replace(to_replace = {'ckd\t': 'ckd', 'notckd': 'not ckd'})
```

```
In [14]: df['class'] = df['class'].map({0: 'no', 1: 'yes'})
df['class'] = pd.to_numeric(df['class'], errors='coerce')
```

```
In [15]: cols = ['diabetes_mellitus', 'coronary_artery_disease', 'class']

for col in cols:
    print(f"{col} has {df[col].unique()} values")

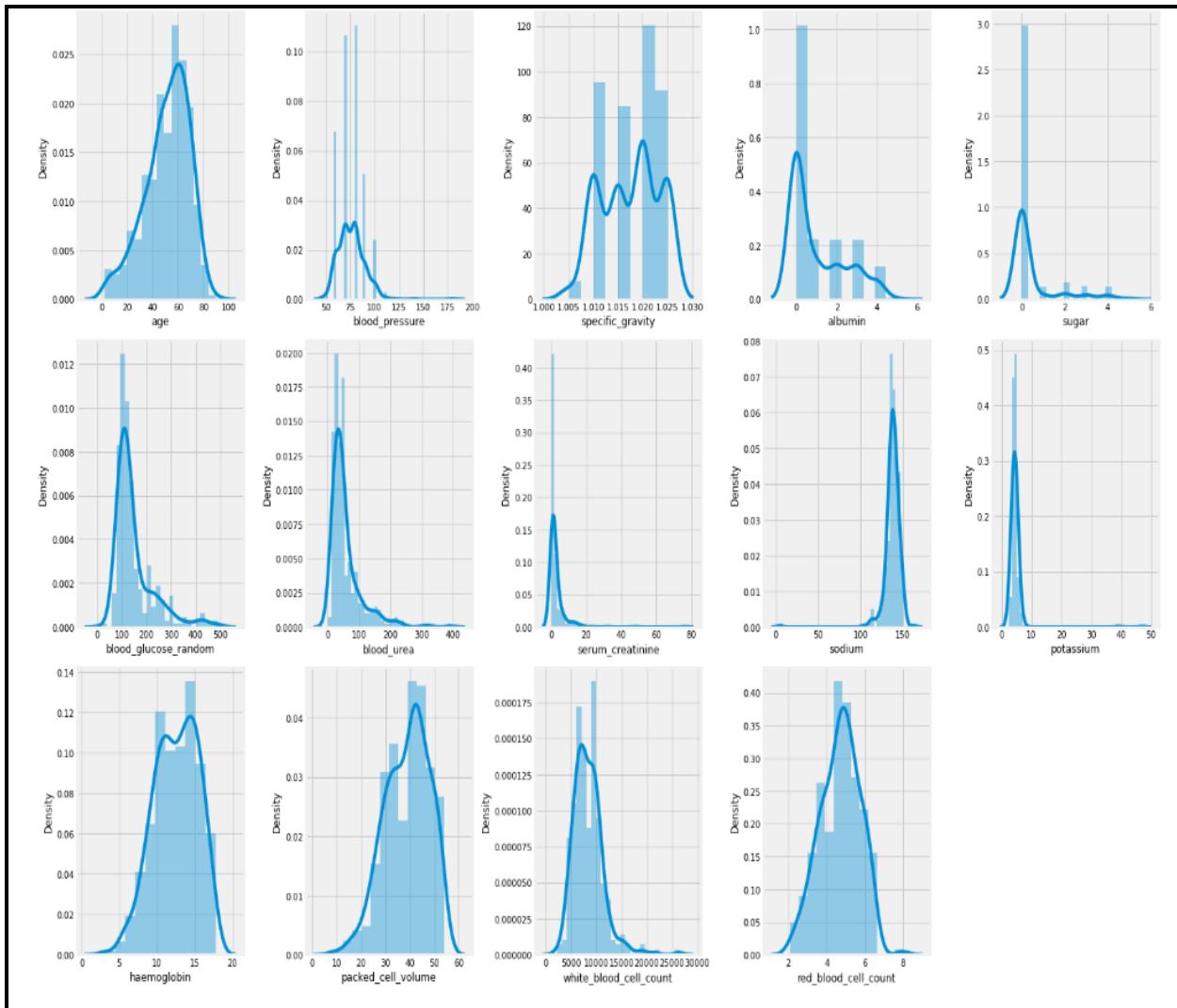
diabetes_mellitus has ['yes' 'no' nan] values
coronary_artery_disease has ['no' 'yes' nan] values
class has [0 1] values
```

```
In [16]: # checking numerical features distribution
plt.figure(figsize = (20, 15))
plotnumber = 1

for column in num_cols:
    if plotnumber <= 14:
        ax = plt.subplot(3, 5, plotnumber)
        sns.distplot(df[column])
        plt.xlabel(column)

    plotnumber += 1

plt.tight_layout()
plt.show()
```



In [17]: # Looking at categorical columns

```
plt.figure(figsize = (20, 15))
plotnumber = 1

for column in cat_cols:
    if plotnumber <= 11:
        ax = plt.subplot(3, 4, plotnumber)
        sns.countplot(df[column], palette = 'rocket')
        plt.xlabel(column)

    plotnumber += 1

plt.tight_layout()
plt.show()
```



In [18]: # heatmap of data

```
plt.figure(figsize = (15, 8))

sns.heatmap(df.corr(), annot = True, linewidths = 2, linecolor = 'lightgrey')
plt.show()
```



```
In [19]: df.columns

Out[19]: Index(['age', 'blood_pressure', 'specific_gravity', 'albumin', 'sugar',
       'red_blood_cells', 'pus_cell', 'pus_cell_clumps', 'bacteria',
       'blood_glucose_random', 'blood_urea', 'serum_creatinine', 'sodium',
       'potassium', 'haemoglobin', 'packed_cell_volume',
       'white_blood_cell_count', 'red_blood_cell_count', 'hypertension',
       'diabetes_mellitus', 'coronary_artery_disease', 'appetite',
       'peda_edema', 'aanemia', 'class'],
      dtype='object')
```

Data Analysis

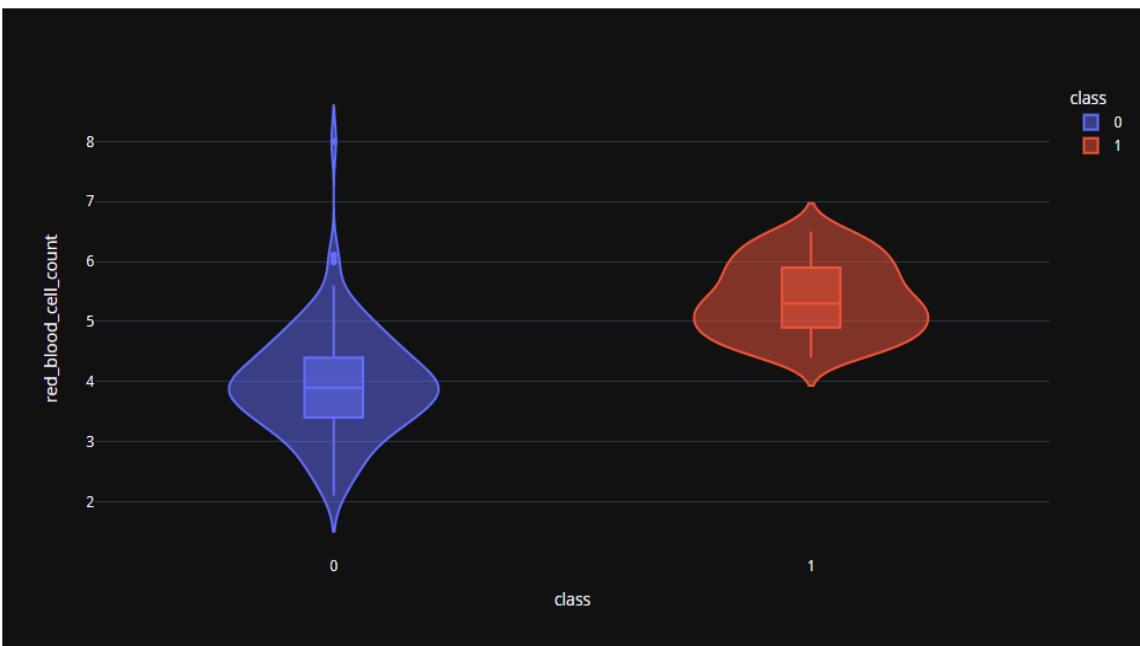
```
In [20]: # defining functions to create plot

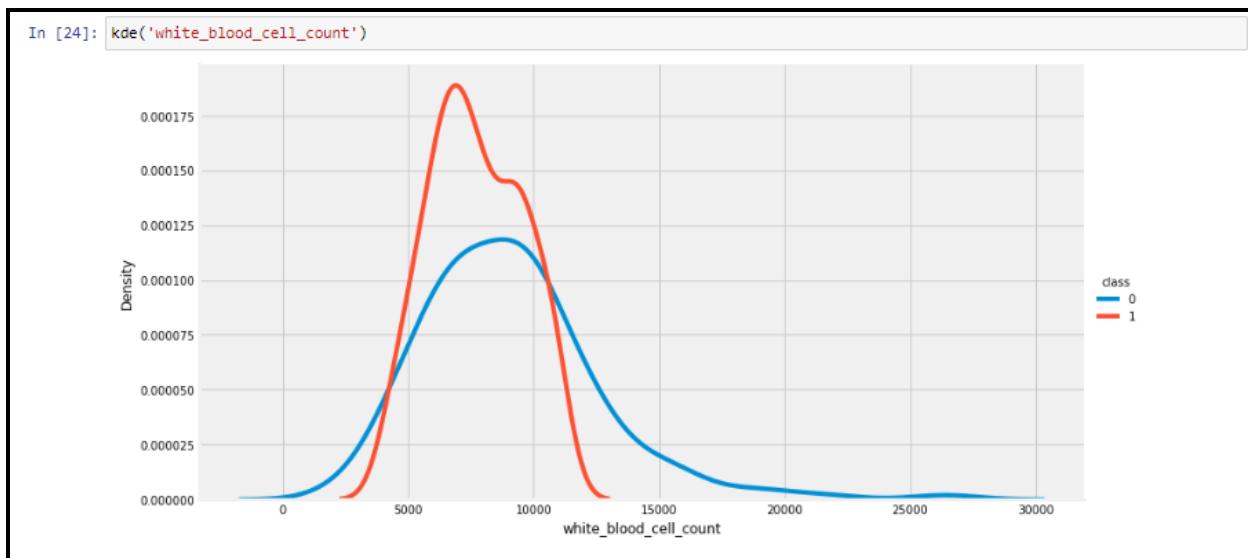
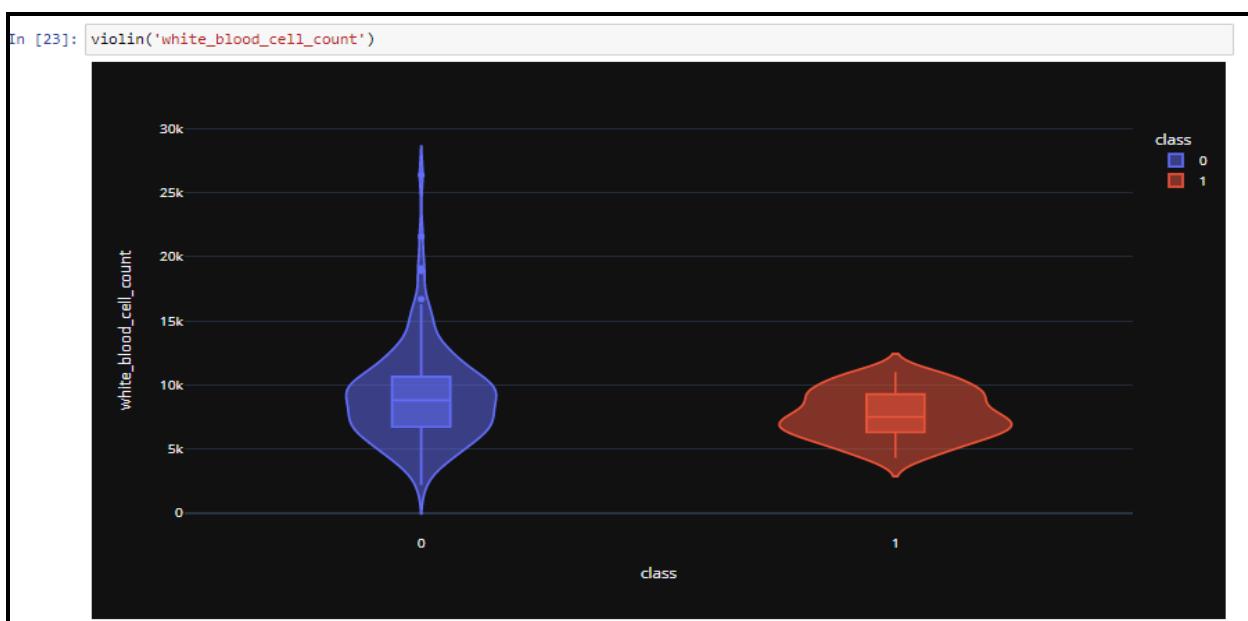
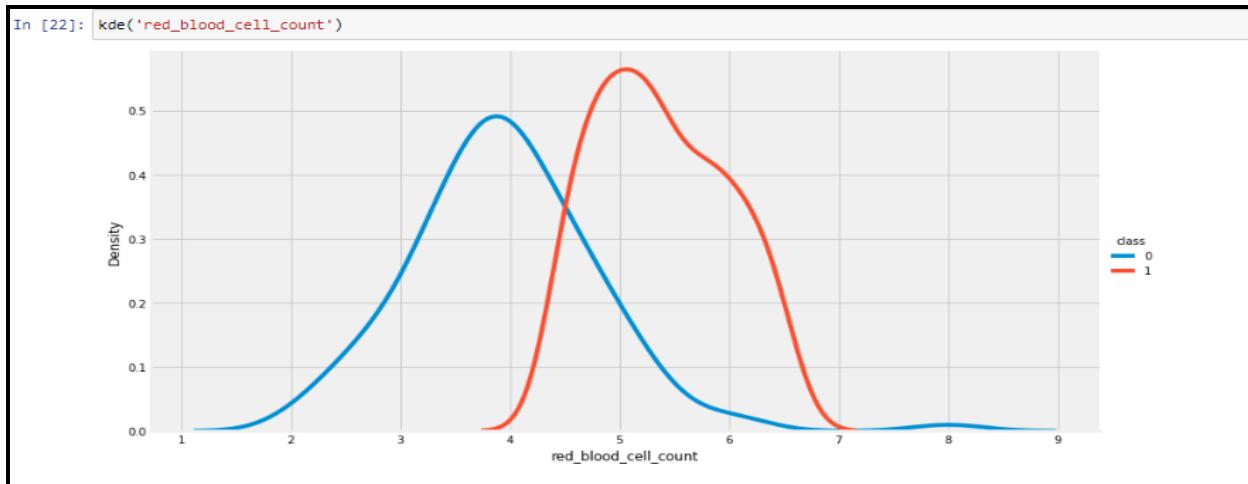
def violin(col):
    fig = px.violin(df, y=col, x="class", color="class", box=True, template = 'plotly_dark')
    return fig.show()

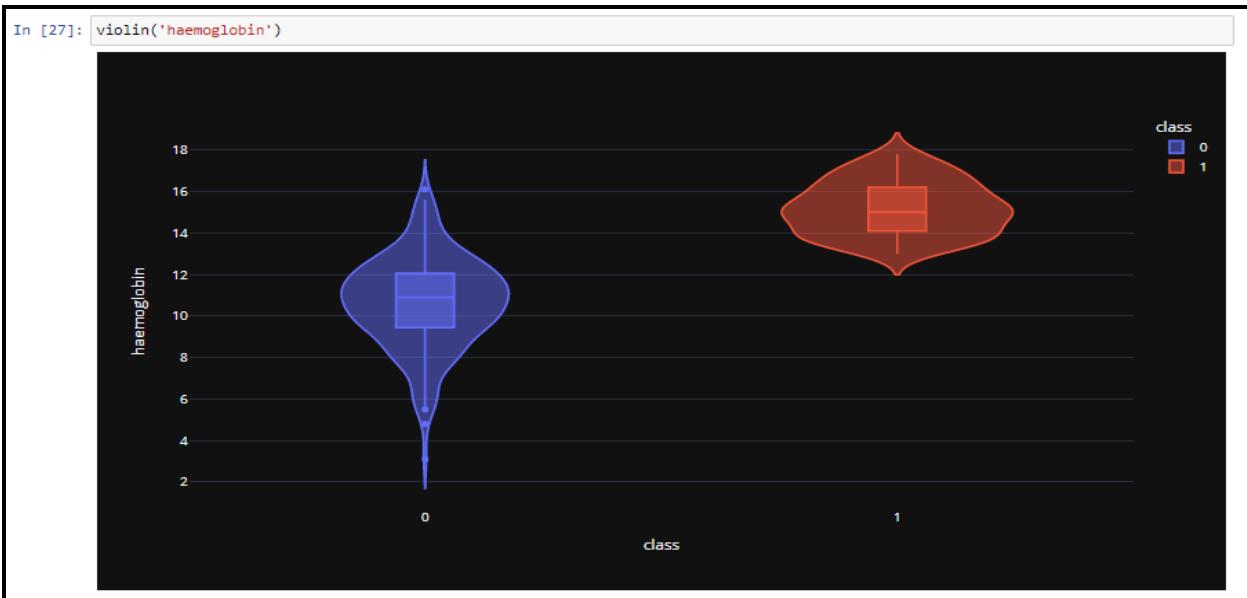
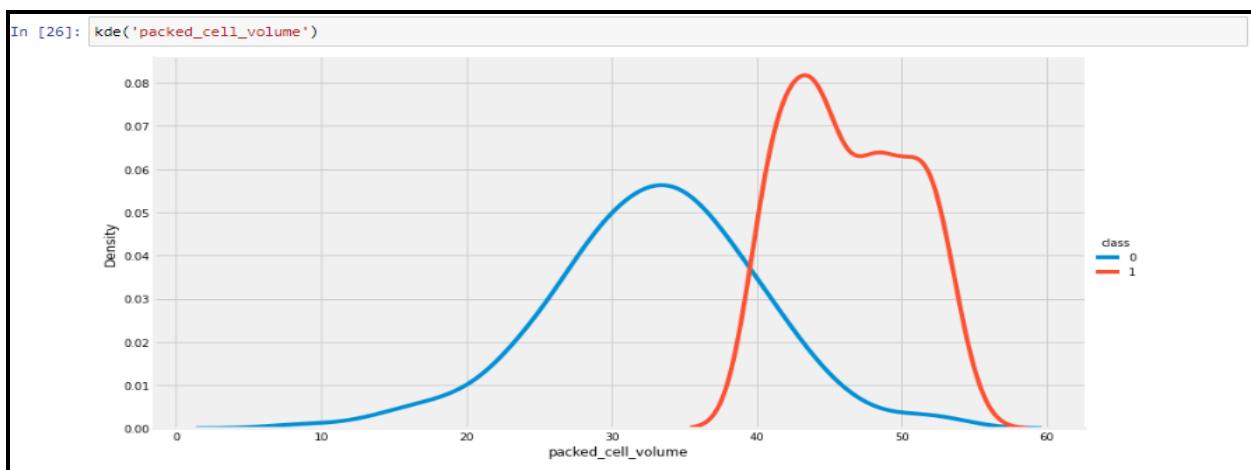
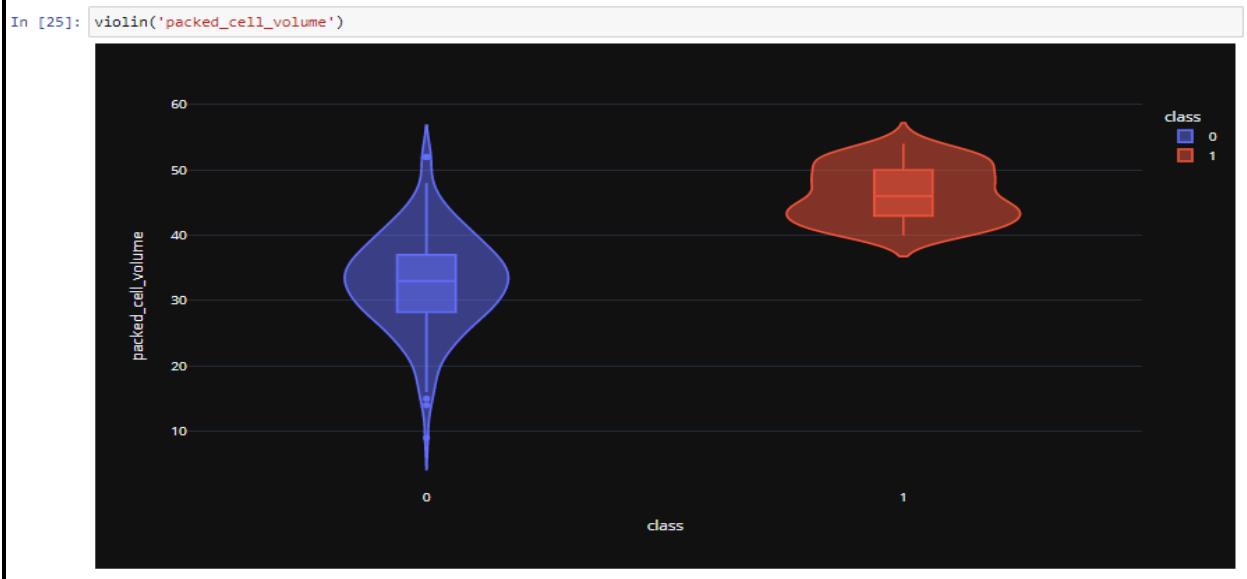
def kde(col):
    grid = sns.FacetGrid(df, hue="class", height = 6, aspect=2)
    grid.map(sns.kdeplot, col)
    grid.add_legend()

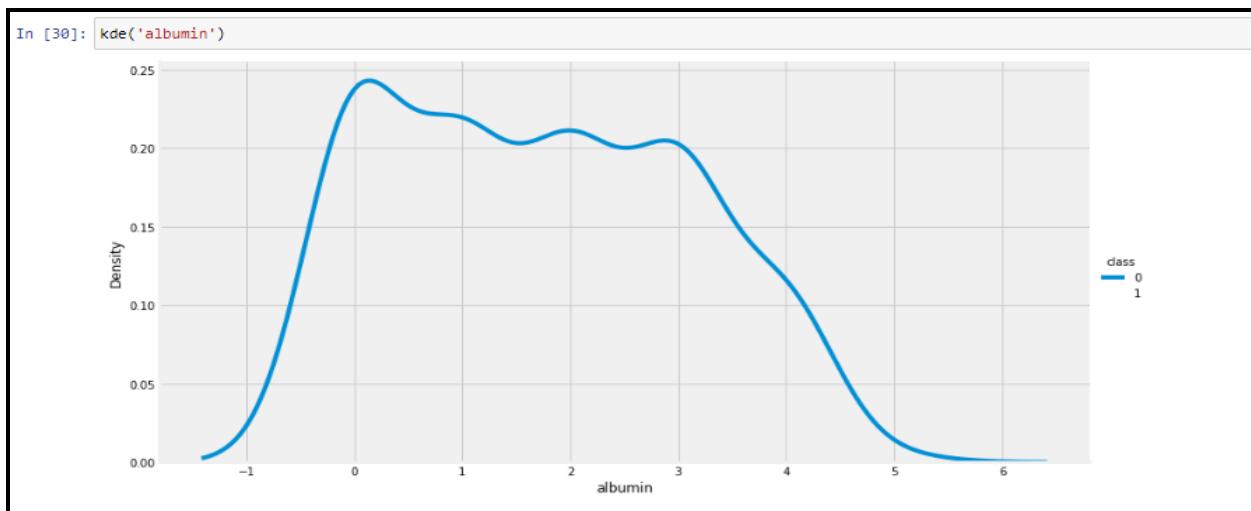
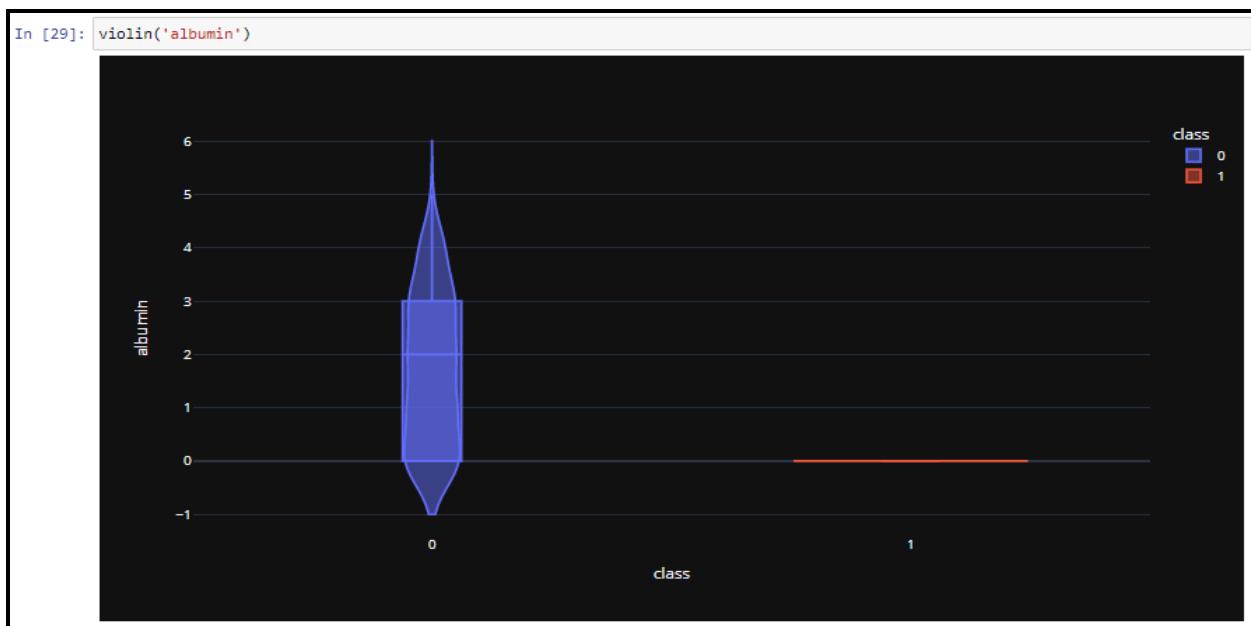
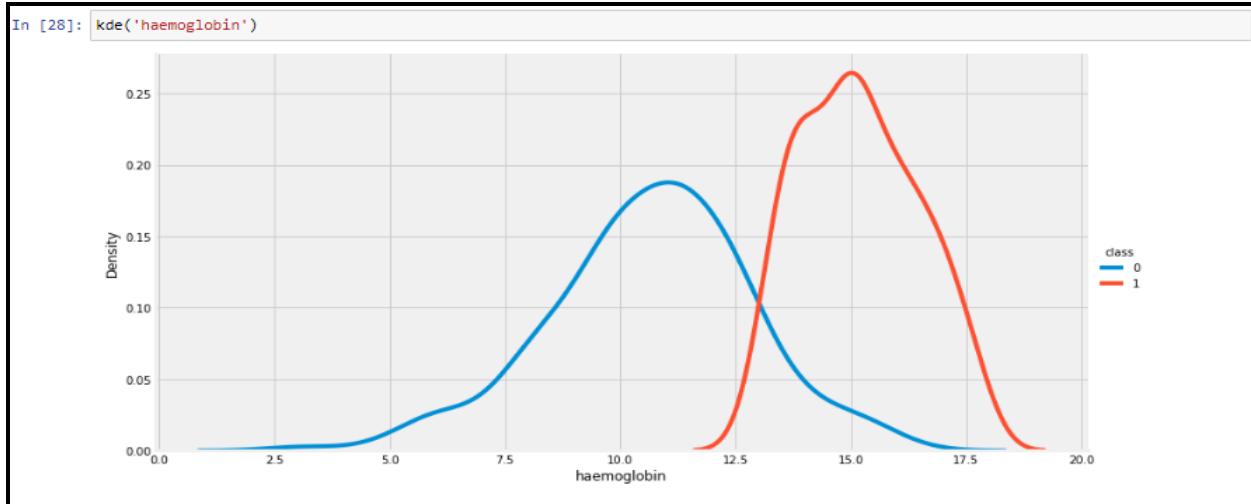
def scatter(col1, col2):
    fig = px.scatter(df, x=col1, y=col2, color="class", template = 'plotly_dark')
    return fig.show()
```

```
In [21]: violin('red_blood_cell_count')
```





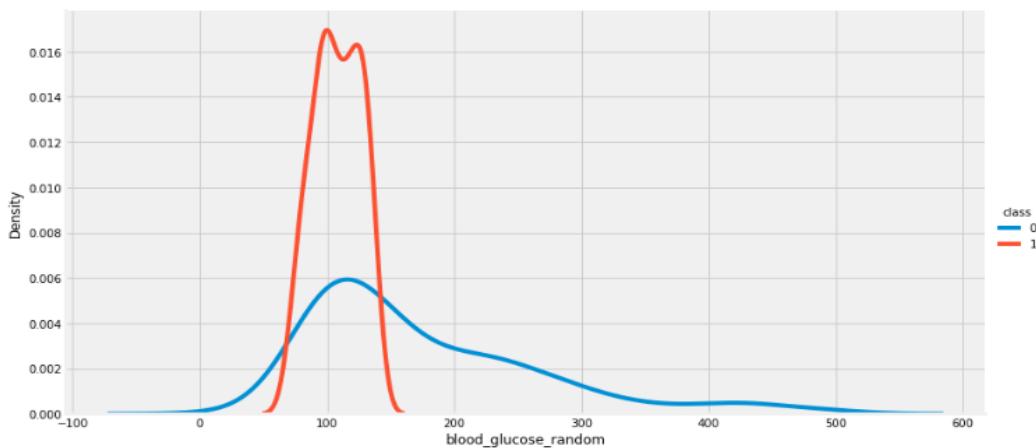




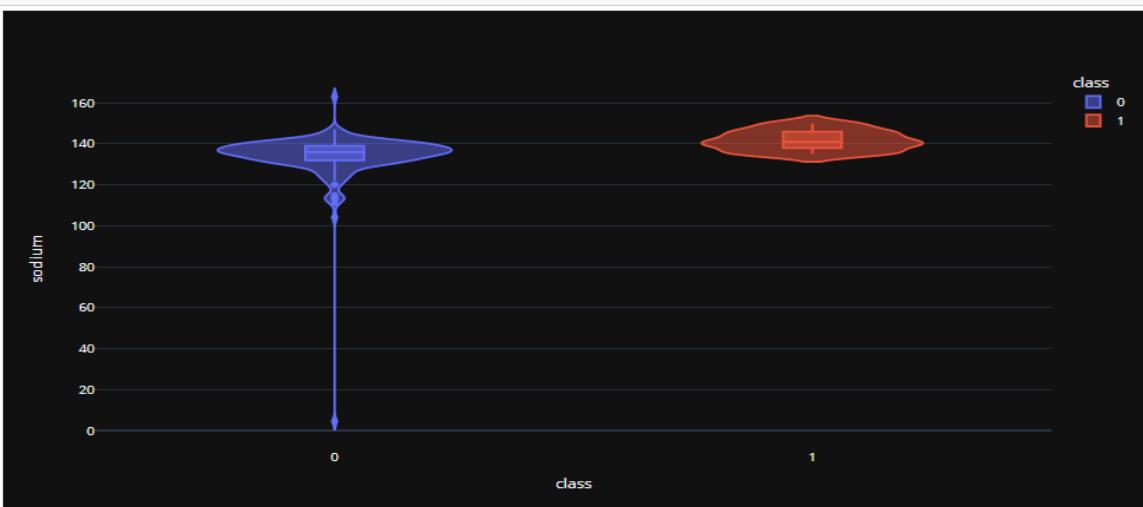
```
In [31]: violin('blood_glucose_random')
```

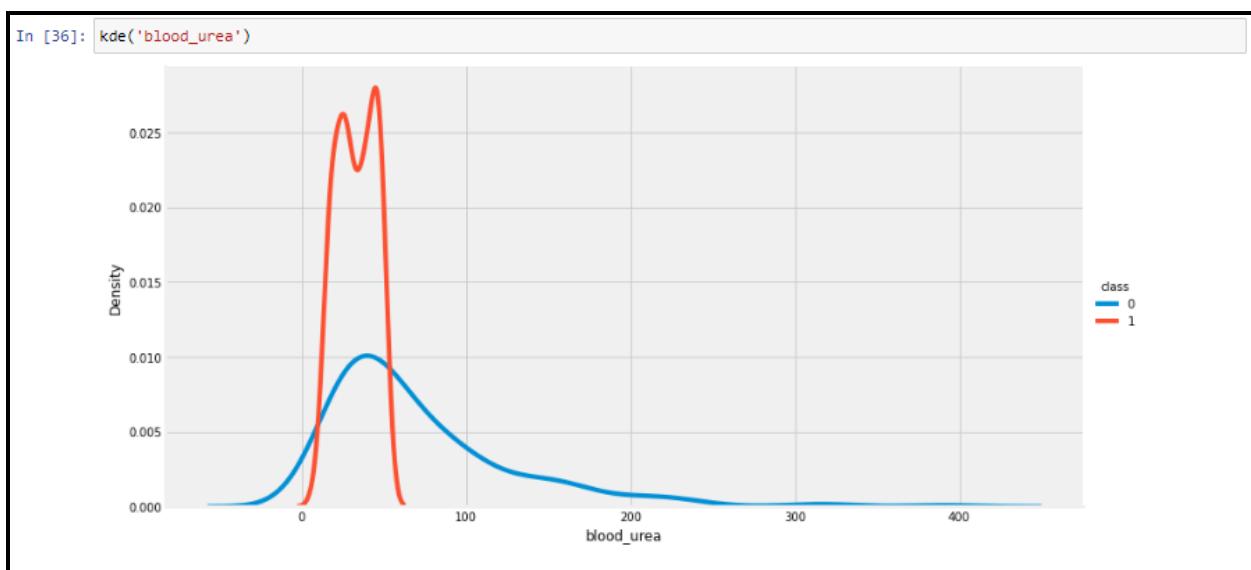
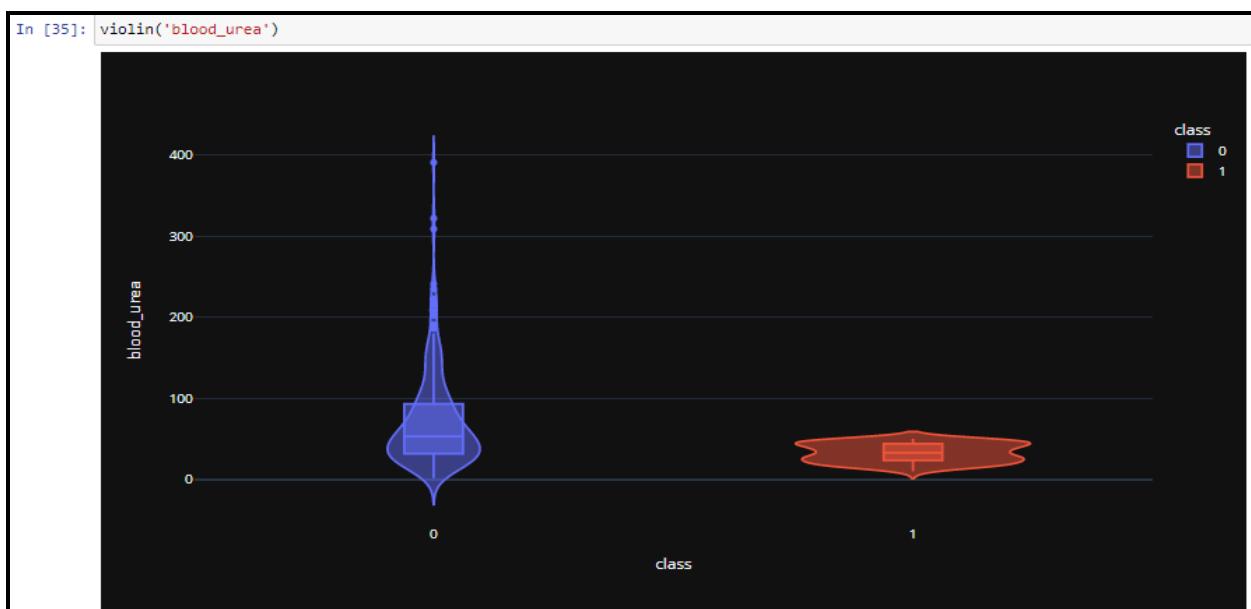
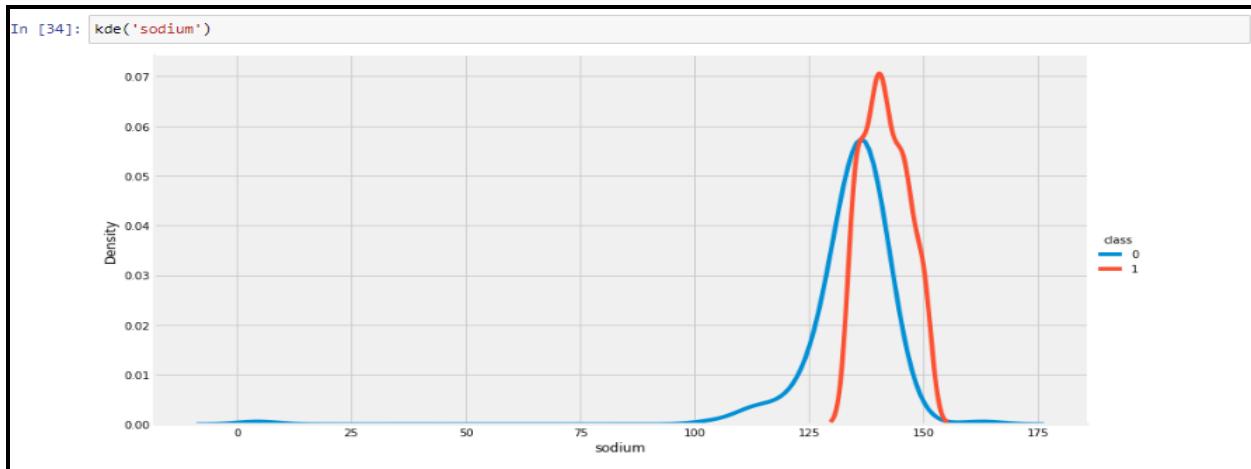


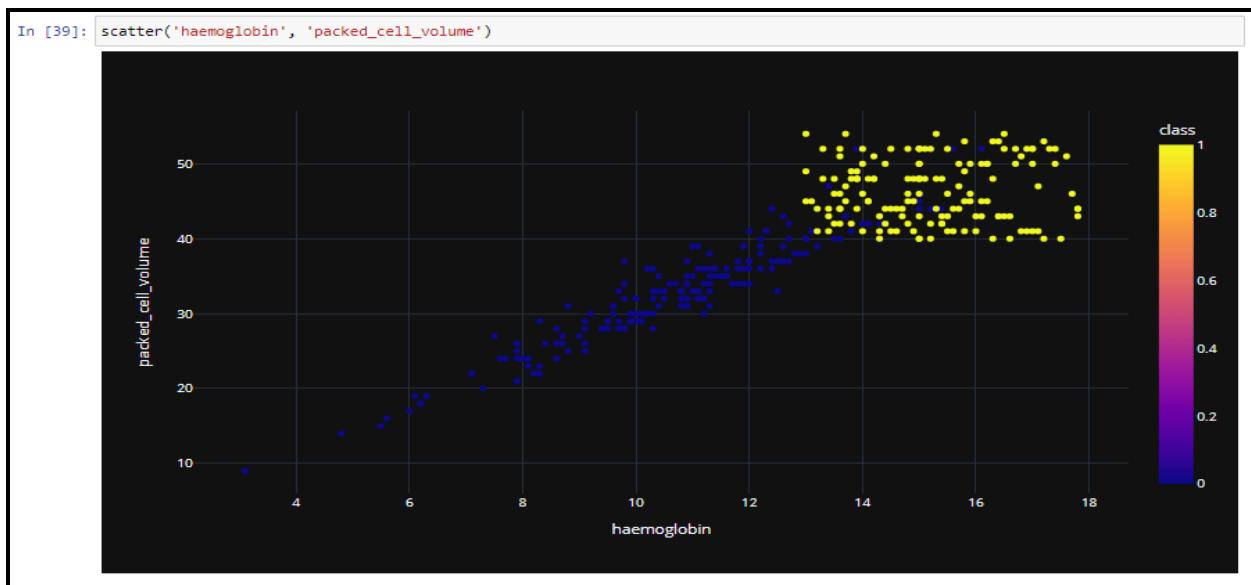
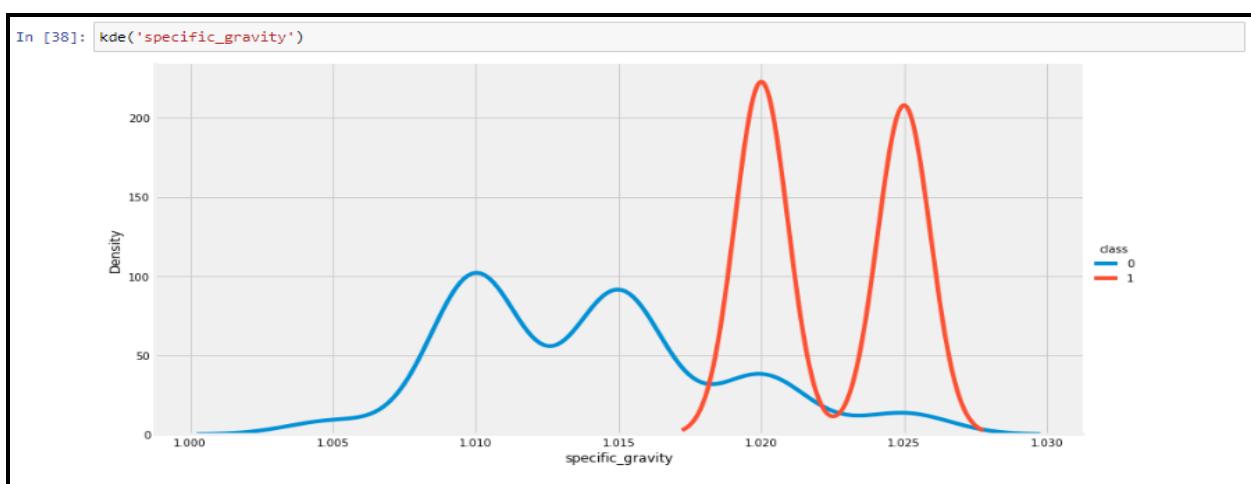
```
In [32]: kde('blood_glucose_random')
```



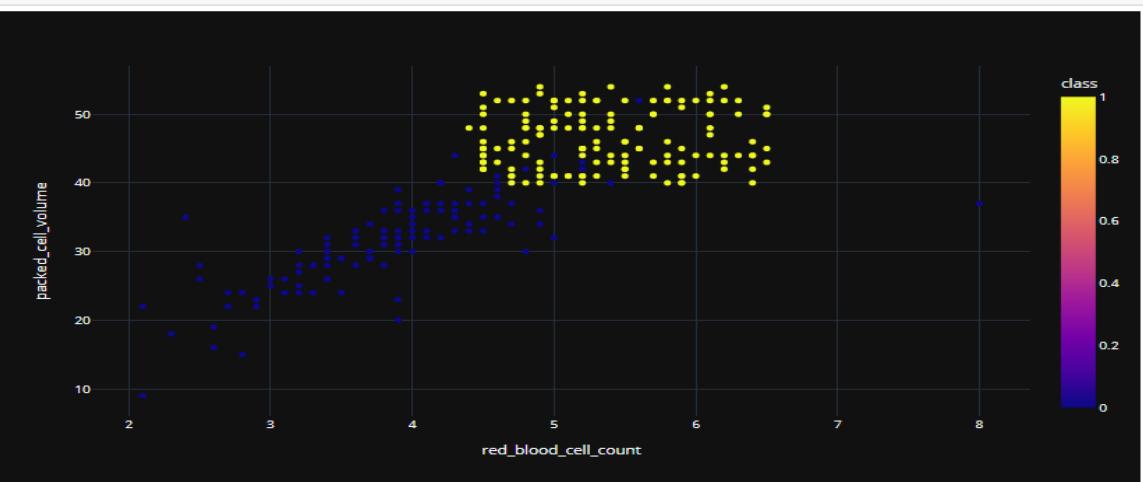
```
In [33]: violin('sodium')
```



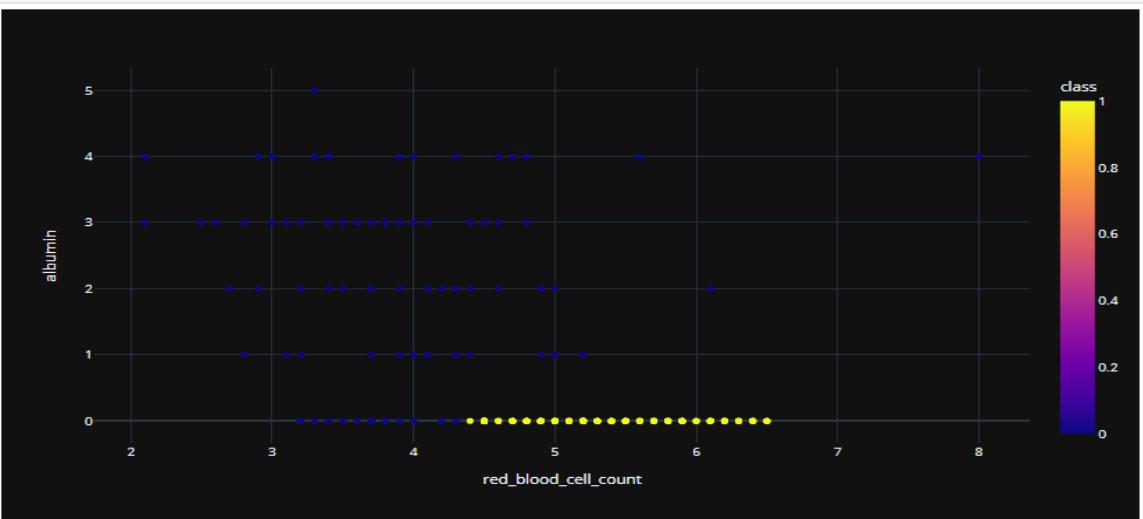


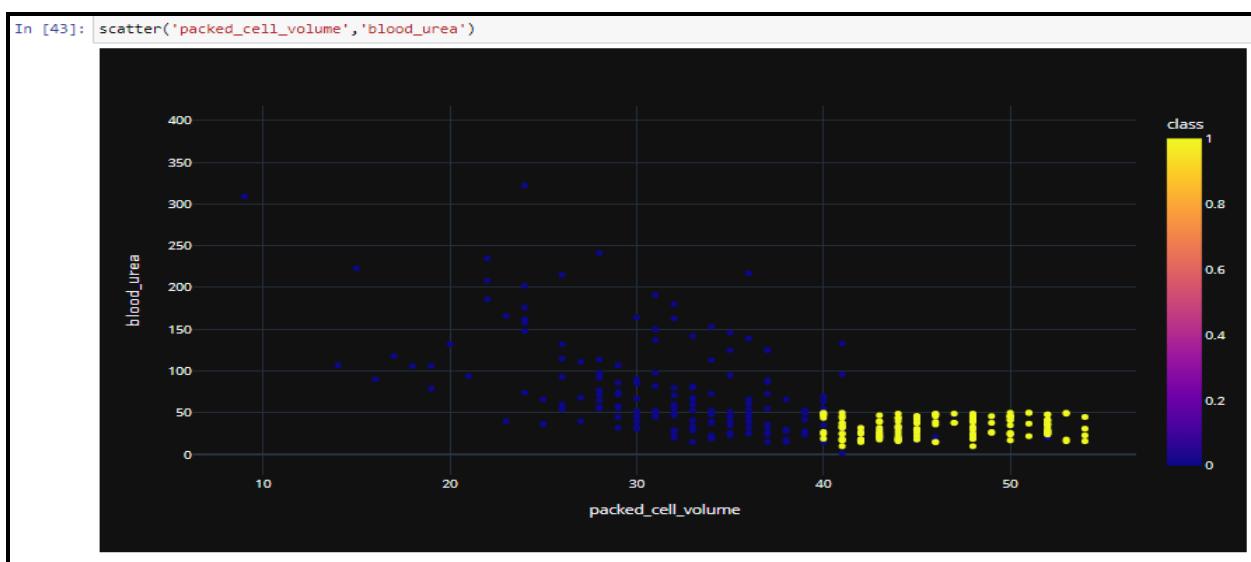
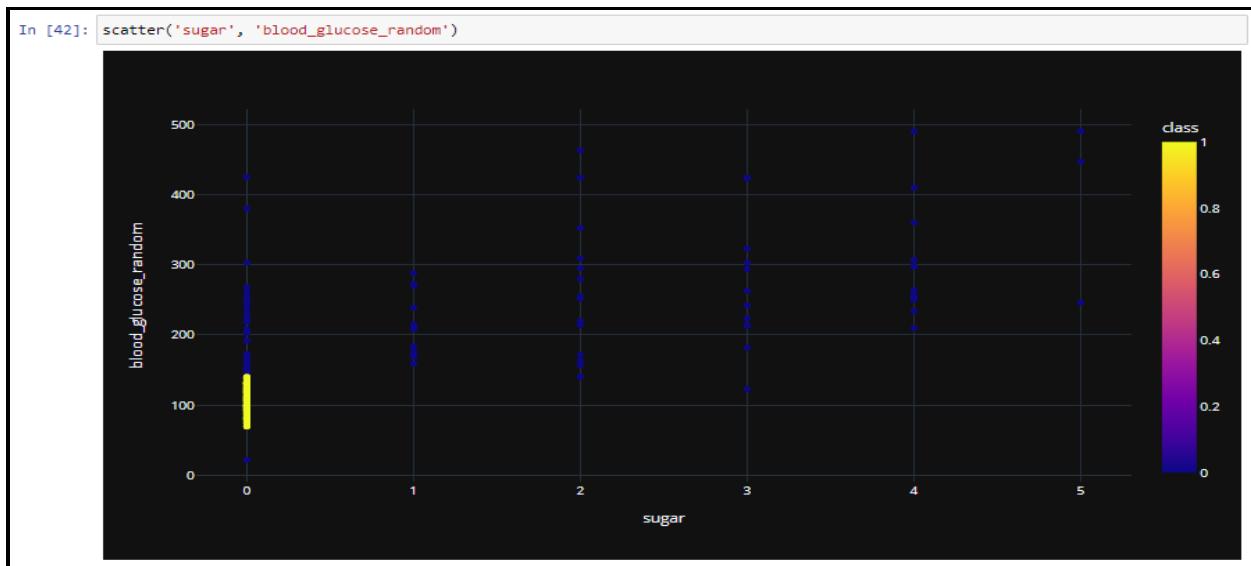


```
In [40]: scatter('red_blood_cell_count', 'packed_cell_volume')
```

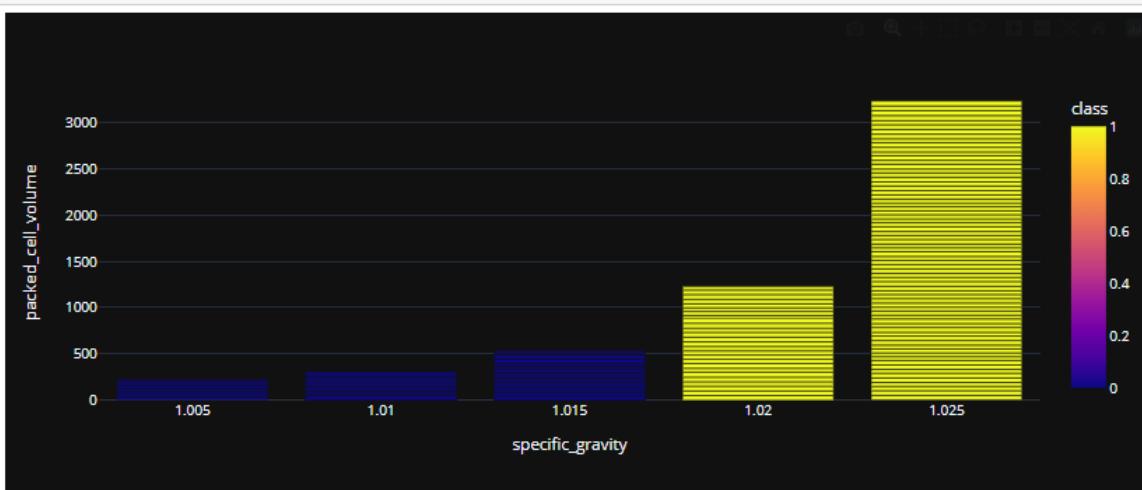


```
In [41]: scatter('red_blood_cell_count', 'albumin')
```

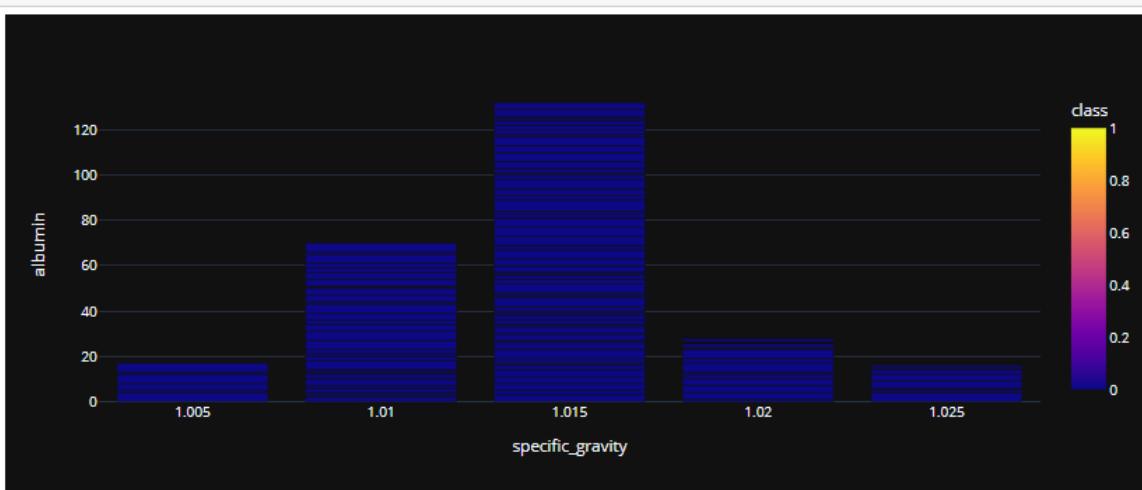




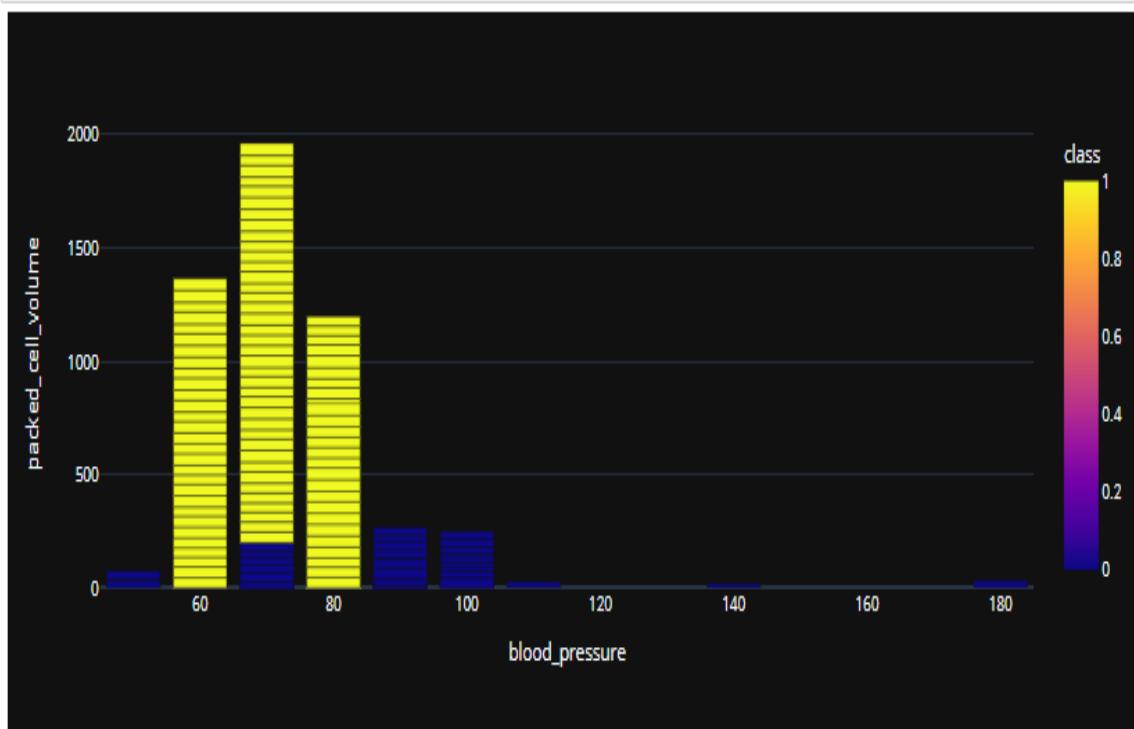
```
In [44]: px.bar(df, x="specific_gravity", y="packed_cell_volume", color='class', barmode='group', template = 'plotly_dark', height = 400)
```



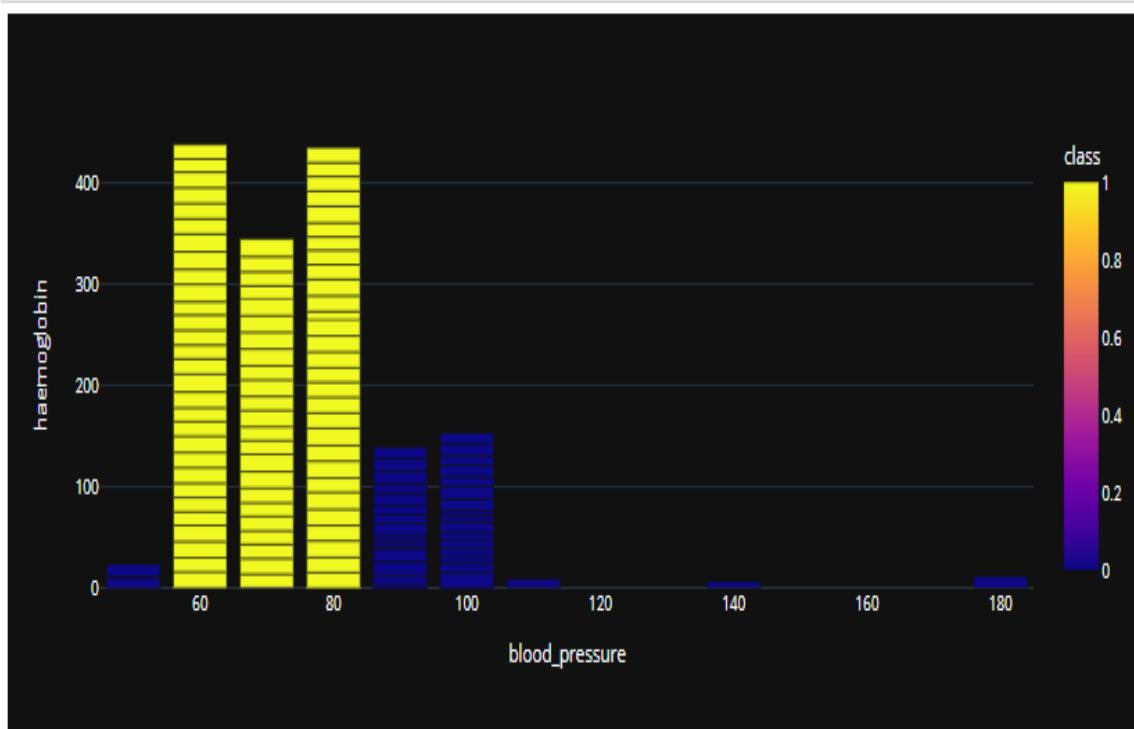
```
In [45]: px.bar(df, x="specific_gravity", y="albumin", color='class', barmode='group', template = 'plotly_dark', height = 400)
```



```
In [46]: px.bar(df, x="blood_pressure", y="packed_cell_volume", color='class', barmode='group', template = 'plotly_dark', height = 400)
```



```
In [47]: px.bar(df, x="blood_pressure", y="haemoglobin", color='class', barmode='group', template = 'plotly_dark', height = 400)
```



Data Pre Processing

```
In [48]: # checking for null values
df.isna().sum().sort_values(ascending = False)
```

```
Out[48]: red_blood_cells      152
red_blood_cell_count       131
white_blood_cell_count     106
potassium                  88
sodium                     87
packed_cell_volume          71
pus_cell                   65
haemoglobin                 52
sugar                      49
specific_gravity            47
albumin                     46
blood_glucose_random        44
blood_urea                  19
serum_creatinine             17
blood_pressure                12
age                          9
bacteria                    4
pus_cell_clumps              4
hypertension                  2
diabetes_mellitus              2
coronary_artery_disease        2
appetite                     1
peda_edema                  1
aanemia                     1
class                        0
dtype: int64
```

```
In [49]: df[num_cols].isnull().sum()
```

```
Out[49]: age                  9
blood_pressure                12
specific_gravity              47
albumin                     46
sugar                      49
blood_glucose_random          44
blood_urea                   19
serum_creatinine               17
sodium                     87
potassium                   88
haemoglobin                  52
packed_cell_volume              71
white_blood_cell_count        106
red_blood_cell_count           131
dtype: int64
```

```
In [50]: df[cat_cols].isnull().sum()
```

```
Out[50]: red_blood_cells      152
pus_cell                   65
pus_cell_clumps              4
bacteria                    4
hypertension                  2
diabetes_mellitus              2
coronary_artery_disease        2
appetite                     1
peda_edema                  1
aanemia                     1
class                        0
dtype: int64
```

```
In [51]: # filling null values, we will use two methods, random sampling for higher null values and
# mean/mode sampling for lower null values
```

```
def random_value_imputation(feature):
    random_sample = df[feature].dropna().sample(df[feature].isna().sum())
    random_sample.index = df[df[feature].isnull()].index
    df.loc[df[feature].isnull(), feature] = random_sample

def impute_mode(feature):
    mode = df[feature].mode()[0]
    df[feature] = df[feature].fillna(mode)
```

```
In [52]: # filling num_cols null values using random sampling method  
  
for col in num_cols:  
    random_value_imputation(col)
```

```
In [53]: df[num_cols].isnull().sum()
```

```
Out[53]: age          0  
blood_pressure      0  
specific_gravity    0  
albumin             0  
sugar               0  
blood_glucose_random 0  
blood_urea           0  
serum_creatinine    0  
sodium              0  
potassium            0  
haemoglobin         0  
packed_cell_volume   0  
white_blood_cell_count 0  
red_blood_cell_count 0  
dtype: int64
```

```
In [54]: # filling "red_blood_cells" and "pus_cell" using random sampling method and rest of cat_cols using mode imputation  
  
random_value_imputation('red_blood_cells')  
random_value_imputation('pus_cell')  
  
for col in cat_cols:  
    impute_mode(col)
```

```
In [55]: df[cat_cols].isnull().sum()
```

```
Out[55]: red_blood_cells      0  
pus_cell                   0  
pus_cell_clumps            0  
bacteria                   0  
hypertension                0  
diabetes_mellitus           0  
coronary_artery_disease     0  
appetite                    0  
peda_edema                 0  
aanemia                     0  
class                       0  
dtype: int64
```

Feature Encoding

```
In [56]: for col in cat_cols:
    print(f"{col} has {df[col].nunique()} categories\n")

red_blood_cells has 2 categories

pus_cell has 2 categories

pus_cell_clumps has 2 categories

bacteria has 2 categories

hypertension has 2 categories

diabetes_mellitus has 2 categories

coronary_artery_disease has 2 categories

appetite has 2 categories

peda_edema has 2 categories

aanemia has 2 categories

class has 2 categories
```

Label encoding

```
In [57]: from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()
for col in cat_cols:
    df[col] = le.fit_transform(df[col])

In [58]: df.head()

Out[58]:
   age  blood_pressure  specific_gravity  albumin  sugar  red_blood_cells  pus_cell  pus_cell_clumps  bacteria  blood_glucose_random  blood_urea  serum_crea
0  48.0           80.0          1.020      1.0     0.0                  1         1             0         0            121.0        36.0
1   7.0           50.0          1.020      4.0     0.0                  1         1             0         0            88.0        18.0
2  62.0           80.0          1.010      2.0     3.0                  1         1             0         0            423.0        53.0
3  48.0           70.0          1.005      4.0     0.0                  1         0             1         0            117.0        56.0
4  51.0           80.0          1.010      2.0     0.0                  1         1             0         0            106.0        26.0
```

7.2 Feature 2:

During Sprint2 we have planned for Model building, comparing and choosing the best model.

Model Building

```
In [59]: ind_col = [col for col in df.columns if col != 'class']
dep_col = 'class'

X = df[ind_col]
y = df[dep_col]

In [60]: # splitting data into training and test set
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.30, random_state = 0)
```

KNN

```
In [61]: from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score, confusion_matrix, classification_report

knn = KNeighborsClassifier()
knn.fit(X_train, y_train)

# accuracy score, confusion matrix and classification report of knn

knn_acc = accuracy_score(y_test, knn.predict(X_test))

print(f"Training Accuracy of KNN is {accuracy_score(y_train, knn.predict(X_train))}")
print(f"Test Accuracy of KNN is {knn_acc} \n")

print(f"Confusion Matrix :- \n{confusion_matrix(y_test, knn.predict(X_test))}\n")
print(f"Classification Report :- \n{classification_report(y_test, knn.predict(X_test))}")
```

Training Accuracy of KNN is 0.775
Test Accuracy of KNN is 0.7

Confusion Matrix :
[[51 21]
 [15 33]]

	precision	recall	f1-score	support
0	0.77	0.71	0.74	72
1	0.61	0.69	0.65	48
accuracy			0.70	120
macro avg	0.69	0.70	0.69	120
weighted avg	0.71	0.70	0.70	120

```
In [62]: from sklearn.tree import DecisionTreeClassifier

dtc = DecisionTreeClassifier()
dtc.fit(X_train, y_train)

# accuracy score, confusion matrix and classification report of decision tree

dtc_acc = accuracy_score(y_test, dtc.predict(X_test))

print(f"Training Accuracy of Decision Tree Classifier is {accuracy_score(y_train, dtc.predict(X_train))}")
print(f"Test Accuracy of Decision Tree Classifier is {dtc_acc} \n")

print(f"Confusion Matrix :- \n{confusion_matrix(y_test, dtc.predict(X_test))}\n")
print(f"Classification Report :- \n {classification_report(y_test, dtc.predict(X_test))}\n")

Training Accuracy of Decision Tree Classifier is 1.0
Test Accuracy of Decision Tree Classifier is 0.95

Confusion Matrix :-
[[71  1]
 [ 5 43]]

Classification Report :-
      precision    recall  f1-score   support
          0       0.93     0.99     0.96      72
          1       0.98     0.90     0.93      48

  accuracy                           0.95      120
 macro avg       0.96     0.94     0.95      120
weighted avg    0.95     0.95     0.95      120
```

```
In [63]: # hyper parameter tuning of decision tree

from sklearn.model_selection import GridSearchCV
grid_param = {
    'criterion' : ['gini', 'entropy'],
    'max_depth' : [3, 5, 7, 10],
    'splitter' : ['best', 'random'],
    'min_samples_leaf' : [1, 2, 3, 5, 7],
    'min_samples_split' : [1, 2, 3, 5, 7],
    'max_features' : ['auto', 'sqrt', 'log2']
}

grid_search_dtc = GridSearchCV(dtc, grid_param, cv = 5, n_jobs = -1, verbose = 1)
grid_search_dtc.fit(X_train, y_train)
```

Fitting 5 folds for each of 1200 candidates, totalling 6000 fits

```
Out[63]: GridSearchCV(cv=5, estimator=DecisionTreeClassifier(), n_jobs=-1,
param_grid={'criterion': ['gini', 'entropy'],
'max_depth': [3, 5, 7, 10],
'max_features': ['auto', 'sqrt', 'log2'],
'min_samples_leaf': [1, 2, 3, 5, 7],
'min_samples_split': [1, 2, 3, 5, 7],
'splitter': ['best', 'random']},
verbose=1)
```

```
In [64]: # best parameters and best score

print(grid_search_dtc.best_params_)
print(grid_search_dtc.best_score_)

{'criterion': 'gini', 'max_depth': 5, 'max_features': 'sqrt', 'min_samples_leaf': 3, 'min_samples_split': 2, 'splitter': 'best'}
0.9821428571428573
```

```
In [65]: # best estimator
dtc = grid_search_dtc.best_estimator_
# accuracy score, confusion matrix and classification report of decision tree
dtc_acc = accuracy_score(y_test, dtc.predict(X_test))
print(f"Training Accuracy of Decision Tree Classifier is {accuracy_score(y_train, dtc.predict(X_train))}")
print(f"Test Accuracy of Decision Tree Classifier is {dtc_acc} \n")
print(f"Confusion Matrix :- \n{confusion_matrix(y_test, dtc.predict(X_test))}\n")
print(f"Classification Report :- \n {classification_report(y_test, dtc.predict(X_test))}")

Training Accuracy of Decision Tree Classifier is 0.9642857142857143
Test Accuracy of Decision Tree Classifier is 0.9583333333333334

Confusion Matrix :-
[[72  0]
 [ 5 43]]

Classification Report :-
      precision    recall  f1-score   support
          0       0.94     1.00     0.97      72
          1       1.00     0.90     0.95      48

   accuracy                           0.96      120
  macro avg       0.97     0.95     0.96      120
weighted avg       0.96     0.96     0.96      120
```

Random Forest Classifier

```
In [66]: from sklearn.ensemble import RandomForestClassifier
rd_clf = RandomForestClassifier(criterion = 'entropy', max_depth = 11, max_features = 'auto', min_samples_leaf = 2, min_samples_
rd_clf.fit(X_train, y_train)
# accuracy score, confusion matrix and classification report of random forest
rd_clf_acc = accuracy_score(y_test, rd_clf.predict(X_test))
print(f"Training Accuracy of Random Forest Classifier is {accuracy_score(y_train, rd_clf.predict(X_train))}")
print(f"Test Accuracy of Random Forest Classifier is {rd_clf_acc} \n")
print(f"Confusion Matrix :- \n{confusion_matrix(y_test, rd_clf.predict(X_test))}\n")
print(f"Classification Report :- \n {classification_report(y_test, rd_clf.predict(X_test))}")

Training Accuracy of Random Forest Classifier is 1.0
Test Accuracy of Random Forest Classifier is 0.9583333333333334

Confusion Matrix :-
[[72  0]
 [ 5 43]]

Classification Report :-
      precision    recall  f1-score   support
          0       0.94     1.00     0.97      72
          1       1.00     0.90     0.95      48

   accuracy                           0.96      120
  macro avg       0.97     0.95     0.96      120
weighted avg       0.96     0.96     0.96      120
```

Ada Boost Classifier

```
In [67]: from sklearn.ensemble import AdaBoostClassifier
ada = AdaBoostClassifier(base_estimator = dtc)
ada.fit(X_train, y_train)

# accuracy score, confusion matrix and classification report of ada boost
ada_acc = accuracy_score(y_test, ada.predict(X_test))

print(f"Training Accuracy of Ada Boost Classifier is {accuracy_score(y_train, ada.predict(X_train))}")
print(f"Test Accuracy of Ada Boost Classifier is {ada_acc} \n")

print(f"Confusion Matrix :- \n{confusion_matrix(y_test, ada.predict(X_test))}\n")
print(f"Classification Report :- \n {classification_report(y_test, ada.predict(X_test))}")

Training Accuracy of Ada Boost Classifier is 1.0
Test Accuracy of Ada Boost Classifier is 0.975

Confusion Matrix :-
[[72  0]
 [ 3 45]]

Classification Report :-
precision    recall   f1-score   support
          0       0.96      1.00      0.98      72
          1       1.00      0.94      0.97      48

      accuracy           0.97      120
     macro avg       0.98      0.97      0.97      120
  weighted avg       0.98      0.97      0.97      120
```

Gradient Boosting Classifier

```
In [68]: from sklearn.ensemble import GradientBoostingClassifier
gb = GradientBoostingClassifier()
gb.fit(X_train, y_train)

# accuracy score, confusion matrix and classification report of gradient boosting classifier
gb_acc = accuracy_score(y_test, gb.predict(X_test))

print(f"Training Accuracy of Gradient Boosting Classifier is {accuracy_score(y_train, gb.predict(X_train))}")
print(f"Test Accuracy of Gradient Boosting Classifier is {gb_acc} \n")

print(f"Confusion Matrix :- \n{confusion_matrix(y_test, gb.predict(X_test))}\n")
print(f"Classification Report :- \n {classification_report(y_test, gb.predict(X_test))}")

Training Accuracy of Gradient Boosting Classifier is 1.0
Test Accuracy of Gradient Boosting Classifier is 0.975

Confusion Matrix :-
[[72  0]
 [ 3 45]]

Classification Report :-
precision    recall   f1-score   support
          0       0.96      1.00      0.98      72
          1       1.00      0.94      0.97      48

      accuracy           0.97      120
     macro avg       0.98      0.97      0.97      120
  weighted avg       0.98      0.97      0.97      120
```

Stochastic Gradient Boosting (SGB)

```
In [69]: sgb = GradientBoostingClassifier(max_depth = 4, subsample = 0.90, max_features = 0.75, n_estimators = 200)
sgb.fit(X_train, y_train)

# accuracy score, confusion matrix and classification report of stochastic gradient boosting classifier

sgb_acc = accuracy_score(y_test, sgb.predict(X_test))

print(f"Training Accuracy of Stochastic Gradient Boosting is {accuracy_score(y_train, sgb.predict(X_train))}")
print(f"Test Accuracy of Stochastic Gradient Boosting is {sgb_acc} \n")

print(f"Confusion Matrix :- \n{confusion_matrix(y_test, sgb.predict(X_test))}\n")
print(f"Classification Report :- \n {classification_report(y_test, sgb.predict(X_test))}\n")

Training Accuracy of Stochastic Gradient Boosting is 1.0
Test Accuracy of Stochastic Gradient Boosting is 0.9833333333333333

Confusion Matrix :-
[[72  0]
 [ 2 46]]

Classification Report :-
precision    recall   f1-score   support
      0       0.97     1.00     0.99      72
      1       1.00     0.96     0.98      48

      accuracy                           0.98      120
     macro avg       0.99     0.98     0.98      120
  weighted avg       0.98     0.98     0.98      120
```

XgBoost

```
In [70]: from xgboost import XGBClassifier

xgb = XGBClassifier(objective = 'binary:logistic', learning_rate = 0.5, max_depth = 5, n_estimators = 150)
xgb.fit(X_train, y_train)

# accuracy score, confusion matrix and classification report of xgboost

xgb_acc = accuracy_score(y_test, xgb.predict(X_test))

print(f"Training Accuracy of XgBoost is {accuracy_score(y_train, xgb.predict(X_train))}")
print(f"Test Accuracy of XgBoost is {xgb_acc} \n")

print(f"Confusion Matrix :- \n{confusion_matrix(y_test, xgb.predict(X_test))}\n")
print(f"Classification Report :- \n {classification_report(y_test, xgb.predict(X_test))}\n")

-----
ModuleNotFoundError: Traceback (most recent call last)
Input In [70], in <cell line: 1>()
----> 1 from xgboost import XGBClassifier
      3 xgb = XGBClassifier(objective = 'binary:logistic', learning_rate = 0.5, max_depth = 5, n_estimators = 150)
      4 xgb.fit(X_train, y_train)

ModuleNotFoundError: No module named 'xgboost'
```

Cat Boost Classifier

```
In [ ]: from catboost import CatBoostClassifier

cat = CatBoostClassifier(iterations=10)
cat.fit(X_train, y_train)

In [ ]: # accuracy score, confusion matrix and classification report of cat boost

cat_acc = accuracy_score(y_test, cat.predict(X_test))

print(f"Training Accuracy of Cat Boost Classifier is {accuracy_score(y_train, cat.predict(X_train))}")
print(f"Test Accuracy of Cat Boost Classifier is {cat_acc} \n")

print(f"Confusion Matrix :- \n{confusion_matrix(y_test, cat.predict(X_test))}\n")
print(f"Classification Report :- \n {classification_report(y_test, cat.predict(X_test))}\n")
```

Extra Trees Classifier

```
In [ ]: from sklearn.ensemble import ExtraTreesClassifier
etc = ExtraTreesClassifier()
etc.fit(X_train, y_train)

# accuracy score, confusion matrix and classification report of extra trees classifier
etc_acc = accuracy_score(y_test, etc.predict(X_test))

print(f"Training Accuracy of Extra Trees Classifier is {accuracy_score(y_train, etc.predict(X_train))}")
print(f"Test Accuracy of Extra Trees Classifier is {etc_acc} \n")

print(f"Confusion Matrix :- \n{confusion_matrix(y_test, etc.predict(X_test))}\n")
print(f"Classification Report :- \n {classification_report(y_test, etc.predict(X_test))}"
```

LGBM Classifier

```
In [ ]: from lightgbm import LGBMClassifier
lgbm = LGBMClassifier(learning_rate = 1)
lgbm.fit(X_train, y_train)

# accuracy score, confusion matrix and classification report of lgbm classifier
lgbm_acc = accuracy_score(y_test, lgbm.predict(X_test))

print(f"Training Accuracy of LGBM Classifier is {accuracy_score(y_train, lgbm.predict(X_train))}")
print(f"Test Accuracy of LGBM Classifier is {lgbm_acc} \n")

print(f"\n{confusion_matrix(y_test, lgbm.predict(X_test))}\n")
print(classification_report(y_test, lgbm.predict(X_test)))
```

Models Comparison

```
In [ ]: models = pd.DataFrame({
    'Model' : [ 'KNN', 'Decision Tree Classifier', 'Random Forest Classifier','Ada Boost Classifier',
                'Gradient Boosting Classifier', 'Stochastic Gradient Boosting', 'XgBoost', 'Cat Boost', 'Extra Trees Classifier'],
    'Score' : [knn_acc, dtc_acc, rd_clf_acc, ada_acc, gb_acc, sgb_acc, xgb_acc, cat_acc, etc_acc]
})

models.sort_values(by = 'Score', ascending = False)

In [ ]: px.bar(data_frame = models, x = 'Score', y = 'Model', color = 'Score', template = 'plotly_dark',
            title = 'Models Comparison')

In [ ]: #Here we find random forest classifier more reliable so, we are using that

In [ ]: # Top 10 Features
feature_scores=pd.DataFrame(rd_clf.feature_importances_,columns=['Score'],index=X_train.columns).sort_values(by='Score',ascending=False)
top10_feature = feature_scores.nlargest(n=10, columns=['Score'])

plt.figure(figsize=(14,6))
g = sns.barplot(x=top10_feature.index, y=top10_feature['Score'])
p = plt.title('Top 10 Features with Random Forest')
p = plt.xlabel('Feature name')
p = plt.ylabel('Random Forest score')
p = g.set_xticklabels(g.get_xticklabels(), horizontalalignment='right')

In [ ]: top10_feature.index

In [ ]: X.columns

In [ ]: for ele in X.columns:
    if ele not in top10_feature.index:
        X = X.drop(ele, axis = 1)

In [ ]: X.head()

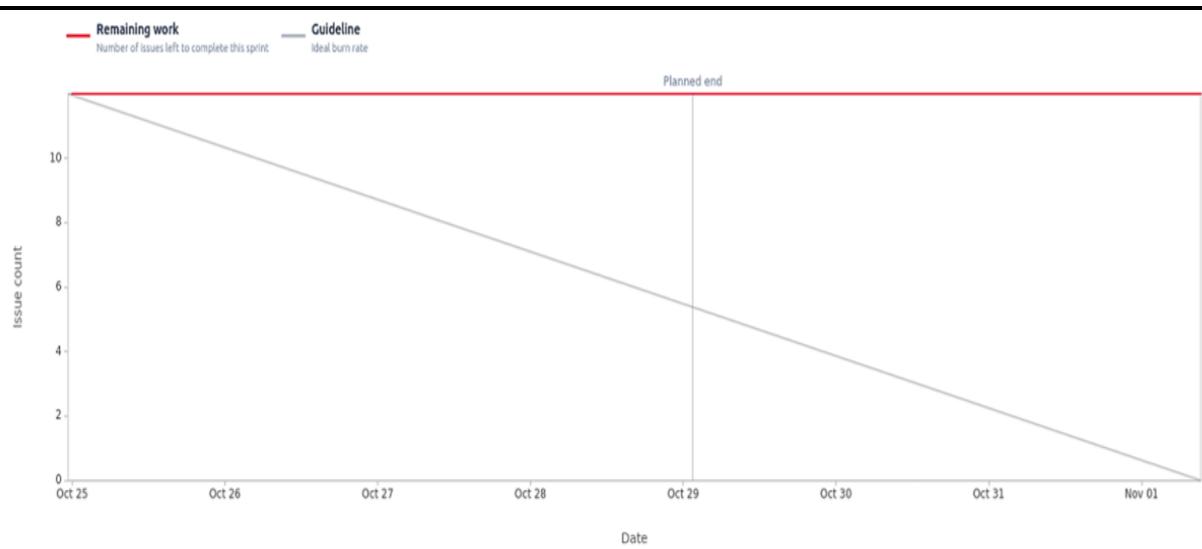
In [ ]: X_train=X_train[['specific_gravity', 'haemoglobin', 'serum_creatinine', 'albumin',
                      'packed_cell_volume', 'diabetes_mellitus', 'hypertension',
                      'blood_glucose_random', 'red_blood_cell_count', 'blood_urea']]
X_test=X_test[['specific_gravity', 'haemoglobin', 'serum_creatinine', 'albumin',
               'packed_cell_volume', 'diabetes_mellitus', 'hypertension',
               'blood_glucose_random', 'red_blood_cell_count', 'blood_urea']]
rd_clf.fit(X_train,y_train)
```

```
In [ ]: # Prediction 1
prediction = rd_clf.predict([[1.025,15.8,1.1,0.0,53.0,0,0,131.0,6.1,18.0]])[0]
if prediction:
    print('Oops! You have Chronic Kidney Disease.')
else:
    print("Great! You don't have Chronic Kidney Disease.")

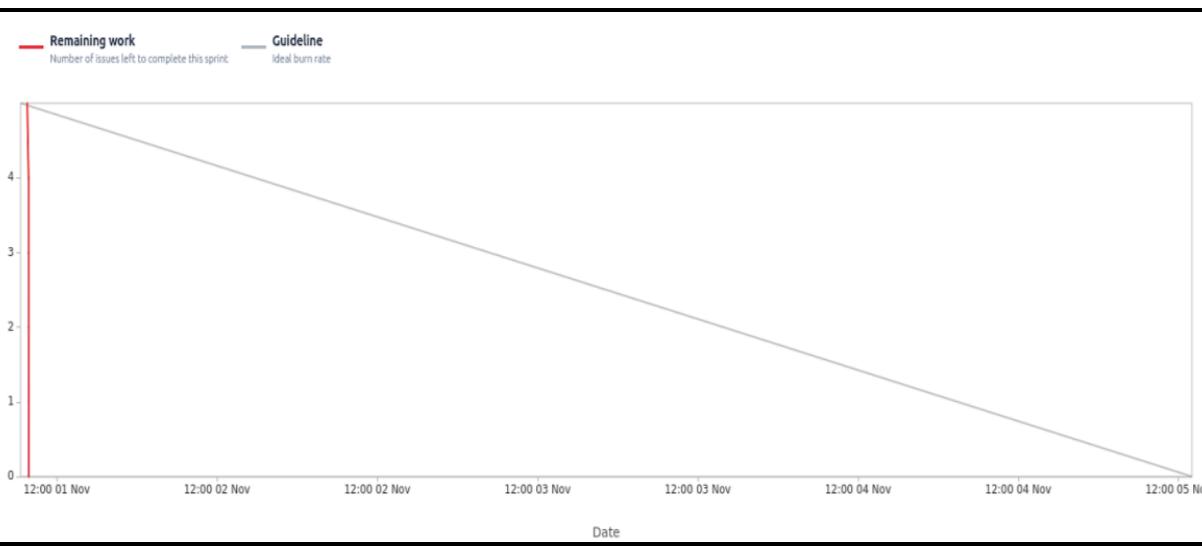
In [ ]: # Prediction 2
prediction = rd_clf.predict([[1.020,15.4,1.2,1.0,44.0,1,1,121.0,5.2,36.0]])[0]
if prediction:
    print('Oops! You have Chronic Kidney Disease.')
else:
    print("Great! You don't have Chronic Kidney Disease.")

In [ ]: import pickle
pickle.dump(rd_clf,open("CKD.pkl","wb"))
```

SPRINT 1 BURNDOWN CHART:



SPRINT 2 BURNDOWN CHART:



7.3 Feature 3:

During Sprint 3 we have planned for Creating HTML files, Build Python code and run the flask app.

app.py:

```

1  from flask import Flask, render_template , request
2
3  app = Flask(__name__ , static_url_path='/static')
4
5  import pickle
6  model = pickle.load(open(r'C:\Users\Praveen\Music\Kidney_flask\CKD.pkl','rb'))
7
8
9  @app.route('/')
10 def home():
11     return render_template("home.html")
12
13 @app.route('/index', methods =['POST','GET'])
14 def index():
15     return render_template("index.html")
16
17 @app.route('/result', methods =['POST','GET'])
18 def result():
19     return render_template("resut.html")
20
21 @app.route('/login', methods =['POST','GET'])
22 def login():
23     p =request.form["sg"]
24     q =request.form["hemo"]
25     r =request.form["sc"]
26     s =request.form["al"]
27     t =request.form["pcv"]
28     u =request.form["u"]
29     if (u=="yes"):
30         u1=1
31     elif (u=="no"):
32         u1=0
33     v =request.form["v"]
34     if (v=="yes"):
35         v1=1
36     elif (v=="no"):
37         v1=0
38     x=request.form["bgr"]
39     y=request.form["cbc"]
40     z=request.form["bu"]
41
42
43     a=[[float(p),float(q),float(r),float(s),float(t),float(u1),float(v1),float(x),float(y),float(z)]]
44
45     pred= model.predict(a)
46     print(pred)
47
48     #if (pred == 1):
49     #    output = "Oops,you have chronic Kidney Disease"
50     #    print("Oops,you have chronic Kidney Disease")
51     #else:
52     #    output = "Great! you dont have chronic kidney disease"
53     #    print("Great! you dont have chronic kidney disease")
54
55     return render_template("result.html",y= pred)
56
57
58 if __name__ == '__main__':
59     app.run(debug = True)

```

Home.html:

```

① Home.html > html > head
1  <!DOCTYPE html>
2  <html lang="en">
3  <head>
4      <meta charset="UTF-8">
5      <meta name="viewport" content="width=device-width, initial-scale=1.0">
6
7      <meta http-equiv="X-UA-Compatible" content="ie=edge">
8
9      <meta name="copyright" content="MACode ID, https://macodeid.com/">
10
11     <title>Chronic Kidney Disease</title>
12
13     <link rel="stylesheet" href="{{url_for('static', filename='css/micons.css')}}">
14
15     <link rel="stylesheet" href="{{ url_for('static', filename='css/bootstrap.css') }}>
16
17     <link rel="stylesheet" href="{{ url_for('static', filename='css/owl.carousel.css') }}>
18
19     <link rel="stylesheet" href="{{ url_for('static', filename='css/animate.css') }}>
20
21     <link rel="stylesheet" href="{{ url_for('static', filename='css/theme.css') }}>
22 </head>
23 <body>
24
25     <!-- Back to top button -->
26     <div class="back-to-top"></div>
27     <nav class="navbar navbar-expand-lg navbar-light shadow-sm">
28         <div class="container">
29             <a class="navbar-brand" href="/"><span class="text-primary">Kidney</span>-Health</a>
30
31         <form action="/">

```

index.html:

```

① index.html > ...
1  <!DOCTYPE html>
2  <html lang="en">
3
4  <head>
5      <meta charset="UTF-8">
6      <title>Chronic Kidney Disease</title>
7
8 </head>
9 <body>
10
11     <div style="color: #rgb(250, 246, 246); class="container">
12         <h2 class="container-heading"><span class="heading_font">Chronic Kidney Disease Prediction</span></h2>
13         
15
16
17     <div style="color: #rgb(252, 246, 246); class="ml-container">
18         <form action="/login" method="post">
19             <h3>Specific gravity:</h3>
20             <input id="first" type="text" name="sg" size="15" required="required" >
21             <br>
22             <h3>Haemoglobin:</h3>
23             <input id="second" type="text" name="hemo" size="15" required="required" >
24             <br>
25             <h3>Serum creatinine:</h3>
26             <input id="third" type="text" name="sc" size="15" required="required" >
27             <br>
28             <h3>Albumin:</h3>
29             <input id="fourth" type="text" name="al" size="15" required="required" >
30             <br>
31             <h3>Packed cell volume:</h3>
32             <input id="fifth" type="text" name="pcv" size="15" required="required" >

```

about.html:

```
about.html > ...
1  <!DOCTYPE html>
2  <html lang="en">
3  <head>
4    <title>Early Detection of Chronic Kidney Disease using Machine Learning</title>
5    <link rel="stylesheet" href="https://stackpath.bootstrapcdn.com/bootstrap/4.3.1/css/bootstrap.min.css" integrity="sha384-gg0yR0iXCbMQv3Xipma34MD+dh1fQ784/j6cY/iJTQU0hcWr7x9Jv0RxT2M Zw1T" crossorigin="anonymous">
6    <link href="https://cdnjs.cloudflare.com/ajax/libs/font-awesome/4.7.0/css/font-awesome.min.css" rel="stylesheet"/>
7    <link rel="canonical" href="https://getbootstrap.com/docs/4.0/examples/sticky-footer/">
8    <script src="https://code.jquery.com/jquery-3.3.1.slim.min.js" integrity="sha384-q8i/X+965Dz0rT7abK41JStQIAqVgRVzbzo5smXkp4YfRvH+8abTE1Pi6jizo" crossorigin="anonymous"></script>
9    <script src="https://cdnjs.cloudflare.com/ajax/libs/popper.js/1.14.7/umd/popper.min.js" integrity="sha384-U02eT0CpHqdsJQ6hJty5KvhptPhzWj9W01c1HTMGa3JDZwrnQq4sF86dIHNDz0W1" crossorigin="anonymous"></script>
10   <script src="https://stackpath.bootstrapcdn.com/bootstrap/4.3.1/js/bootstrap.min.js" integrity="sha384-JjSmVgyd0p3pXB1rRibZUAYoIIy6OrQ6VrjIEaFF/nJGzIxFDsf4x0xIM+B07jRM" crossorigin="anonymous"></script>
11
12 <style>
13   html, body{ height:100%; margin:0; }
14 header{ height:50px; }
15 footer{ height:75px; background:#black; }
16
17
18 body{
19   display:flex;
20   flex-direction:column;
21 }
22
23 footer{
24   padding:10px;
25   margin-top:auto;
26   margin-bottom: auto;
27 }
```

result:

```
result.html > Open HTML  
1  <html>  
2   <head>  
3     <title>Early Detection of Chronic Kidney Disease using Machine Learning</title>  
4     <link rel="stylesheet" href="style.css">  
5     <link href="https://fonts.googleapis.com/css?family=Poppins:100,200,300,400,600,700&display=swap" rel="stylesheet">  
6     <link rel="stylesheet" href="https://stackpath.bootstrapcdn.com/font-awesome/4.7.0/css/font-awesome.min.css">  
7   </head>  
8   <body style="text-align: center;">  
9     <div style="background-color: #f0f0f0; text-align: center;">  
10      <h1>Chronic Kidney Disease Detection</h1>  
11    </div>  
12    <br/>  
13    <br/>  
14    {  
15      if y==1{  
16        <div>  
17          <h1><b><u>Medical Result</u></b></h1>  
18          <h1><b>Your Condition is normal.</b></h1>  
19          <h2><b>you are not having chronic kidney disease.</b></h2>  
20          Chronic Kidney Disease Prediction</b><br>This is a machine learning project that is trained on a collected data of people who are infected by this disease and some other people. It includes a lot of data about the individual and I used that feature to make an optimal model that will predict if someone is suffering from this disease or not. Predictions have been made on patients' kidney data to determine whether there are any clear indications of chronic kidney disease. | <b>Home Prediction</b> |
| <b>STAGES OF CKD?</b><br>CKD is divided into 5 stages:-<br>•CKD stage 1 is eGFR greater than 90 ml/min, which is normal but there are some signs of kidney damage on other tests.<br>•CKD stage 2 is eGFR 60-90. This is mildly decreased with some sign of kidney damage on other tests.<br>•CKD stage 3 is eGFR 45-59 ml/min, a mild to moderate reduction in kidney function.<br>•CKD stage 3 bis eGFR 30-44 ml/min, a moderate to severe reduction in kidney function.<br>•CKD stage 4 is eGFR 15-29 ml/min, a severe reduction in kidney function. You may need additional medications to support loss of certain functions of the kidneys.<br>•CKD stage 5 is eGFR less than 15 ml/min, established kidney failure. Very likely to experience symptoms of kidney failure, when dialysis or a kidney transplant may be needed. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                        |
| <b>What causes Chronic Kidney Disease?</b><br>The two most common causes of CKD are diabetes and high blood pressure.<br>•Diabetes means that your blood sugar is too high, which can damage your kidneys.<br>•High blood pressure means that the force of blood in your blood vessels is too strong, which can damage your blood vessels lead to CKD.<br>•Glomerulonephritis, Polycystic kidney disease, Lupus nephritis, Kidney cancer                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Data Exploration and visualization</b><br>•CKD Prediction.ipynb: Jupyter notebook with a step-by-step analysis of kidney data to predict chronic kidney disease.<br>•Kidney_disease_train.csv: messages created by thepublic in the native language, converted into english.<br>•Kidney_disease_test.csv: categories into which messages fall; water, medical, etc.<br>•Kidney_failure.jpg: a drawing of a functioning kidney and a failed kidney.                                        | <b>CKD Prediction</b>  |

result image:

Chronic Kidney Disease Detection

{% if y==1%}

**Medical Result**

Your Condition is normal.

you are not having chronic kidney disease.



{% else%}

**Medical Result**

Your Condition is abnormal.

You are having chronic kidney disease.



## 7.4 Feature 4:

In sprint 4 we have trained the model in IBM cloud, deployed it and integrated the scoring endpoint with the flask app.

### IBM\_Model:

```
In [1]: # necessary imports

import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import plotly.express as px

import warnings
warnings.filterwarnings('ignore')

plt.style.use('fivethirtyeight')
%matplotlib inline
pd.set_option('display.max_columns', 26)

In [2]: # Loading data
import os, types
import pandas as pd
from botocore.client import Config
import ibm_boto3
import os, types
import os, types
import pandas as pd
from botocore.client import Config
import os, types
import pandas as pd
from botocore.client import Config
import ibm_boto3

def __iter__(self): return 0

@hidden_cell
The following code accesses a file in your IBM Cloud Object Storage. It includes your credentials.
You might want to remove those credentials before you share the notebook.
cos_client = ibm_boto3.client(service_name='s3',
 ibm_api_key_id='BXpwoNyVMBGUPVJZfLmbNC8VALJHC06CUjkyjQ0szJ',
 ibm_auth_endpoint="https://iam.cloud.ibm.com/oidc/token",
 config=Config(signature_version='oauth'),
 endpoint_url='https://s3.private.us.cloud-object-storage.appdomain.cloud')

bucket = 'kidneydiseaseprediction-donotdelete-pr-lxhzw2csr5ovmw'
object_key = 'chronickidneydisease.csv'

body = cos_client.get_object(Bucket=bucket,Key=object_key)['Body']
add missing __iter__ method, so pandas accepts body as file-like object
if not hasattr(body, "__iter__"): body.__iter__ = types.MethodType(__iter__, body)
```

```

df_data_3 = pd.read_csv(body)
df_data_3.head()
import ibm_boto3

def __iter__(self): return 0

@hidden_cell
The following code accesses a file in your IBM Cloud Object Storage. It includes your credentials.
You might want to remove those credentials before you share the notebook.
cos_client = ibm_boto3.client(service_name='s3',
 ibm_api_key_id='BXpwoNyVMbGUPVJTFkLmbNC8VALJHC06CUjkYjQOsJ',
 ibm_auth_endpoint="https://iam.cloud.ibm.com/oidc/token",
 config=Config(signature_version='oauth'),
 endpoint_url='https://s3.private.us.cloud-object-storage.appdomain.cloud')

bucket = 'kidneydiseaseprediction-donotdelete-pr-lxhw2csr5ovmv'
object_key = 'chronickidneydisease.csv'

body = cos_client.get_object(Bucket=bucket,Key=object_key)['Body']
add missing __iter__ method, so pandas accepts body as file-like object
if not hasattr(body, "__iter__"): body.__iter__ = types.MethodType(__iter__, body)

df_data_2 = pd.read_csv(body)
df_data_2.head()
import pandas as pd
from botocore.client import Config
import ibm_boto3

def __iter__(self): return 0

@hidden_cell
The following code accesses a file in your IBM Cloud Object Storage. It includes your credentials.
You might want to remove those credentials before you share the notebook.
cos_client = ibm_boto3.client(service_name='s3',
 ibm_api_key_id='BXpwoNyVMbGUPVJTFkLmbNC8VALJHC06CUjkYjQOsJ',
 ibm_auth_endpoint="https://iam.cloud.ibm.com/oidc/token",
 config=Config(signature_version='oauth'),
 endpoint_url='https://s3.private.us.cloud-object-storage.appdomain.cloud')

bucket = 'kidneydiseaseprediction-donotdelete-pr-lxhw2csr5ovmv'
object_key = 'chronickidneydisease.csv'

body = cos_client.get_object(Bucket=bucket,Key=object_key)['Body']
add missing __iter__ method, so pandas accepts body as file-like object
if not hasattr(body, "__iter__"): body.__iter__ = types.MethodType(__iter__, body)

df_data_1 = pd.read_csv(body)
df_data_1.head()
def __iter__(self): return 0

```

```
@hidden_cell
The following code accesses a file in your IBM Cloud Object Storage. It includes your credentials.
You might want to remove those credentials before you share the notebook.

cos_client = ibm_boto3.client(service_name='s3',
 ibm_api_key_id='BXpwoLlyVMbGUPVJTZfkLmbNC8VALJHC06CUjkYjQ0szJ',
 ibm_auth_endpoint="https://iam.cloud.ibm.com/oidc/token",
 config=Config(signature_version='oauth'),
 endpoint_url='https://s3.private.us.cloud-object-storage.appdomain.cloud')

bucket = 'kidneydiseaseprediction-donotdelete-pr-lxhwz2csr5ovmw'
object_key = 'chronickidneydisease.csv'

body = cos_client.get_object(Bucket=bucket,Key=object_key)['Body']
add missing __iter__ method, so pandas accepts body as file-like object
if not hasattr(body, "__iter__"): body.__iter__ = types.MethodType(__iter__, body)

df = pd.read_csv(body)
df.head()
```

Out[2]:

|   | <b>id</b> | <b>age</b> | <b>bp</b> | <b>sg</b> | <b>al</b> | <b>su</b> | <b>rbc</b> | <b>pc</b> | <b>pcc</b> | <b>ba</b>  | <b>bgr</b> | <b>bu</b> | <b>sc</b> | <b>sod</b> | <b>pot</b> | <b>hemo</b> | <b>pcv</b> | <b>wc</b> | <b>rc</b> | <b>htn</b> | <b>dm</b> | <b>cad</b> | <b>appet</b> | <b>pe</b> | <b>ane</b> | <b>classification</b> |
|---|-----------|------------|-----------|-----------|-----------|-----------|------------|-----------|------------|------------|------------|-----------|-----------|------------|------------|-------------|------------|-----------|-----------|------------|-----------|------------|--------------|-----------|------------|-----------------------|
| 0 | 0         | 48.0       | 80.0      | 1.020     | 1.0       | 0.0       | NaN        | normal    | notpresent | notpresent | 1210       | 36.0      | 1.2       | NaN        | NaN        | 15.4        | 44         | 7800      | 5.2       | yes        | yes       | no         | good         | no        | no         | ckd                   |
| 1 | 1         | 7.0        | 50.0      | 1.020     | 4.0       | 0.0       | NaN        | normal    | notpresent | notpresent | NaN        | 18.0      | 0.8       | NaN        | NaN        | 11.3        | 38         | 6000      | NaN       | no         | no        | no         | good         | no        | no         | ckd                   |
| 2 | 2         | 62.0       | 80.0      | 1.010     | 2.0       | 3.0       | normal     | normal    | notpresent | notpresent | 4230       | 53.0      | 1.8       | NaN        | NaN        | 9.6         | 31         | 7500      | NaN       | no         | yes       | no         | poor         | no        | yes        | ckd                   |
| 3 | 3         | 48.0       | 70.0      | 1.005     | 4.0       | 0.0       | normal     | abnormal  | present    | notpresent | 1170       | 56.0      | 3.8       | 111.0      | 2.5        | 11.2        | 32         | 6700      | 3.9       | yes        | no        | no         | poor         | yes       | yes        | ckd                   |
| 4 | 4         | 51.0       | 80.0      | 1.010     | 2.0       | 0.0       | normal     | normal    | notpresent | notpresent | 1060       | 26.0      | 1.4       | NaN        | NaN        | 11.6        | 35         | 7300      | 4.6       | no         | no        | no         | good         | no        | no         | ckd                   |

In [3]:

```
df.shape
```

Out[3]:

In [4]:

```
dropping id column
df.drop('id', axis = 1, inplace = True)
```

In [5]:

```
rename column names to make it more user-friendly

df.columns = ['age', 'blood_pressure', 'specific_gravity', 'albumin', 'sugar', 'red_blood_cells', 'pus_cell',
 'pus_cell_clumps', 'bacteria', 'blood_glucose_random', 'blood_urea', 'serum_creatinine', 'sodium',
 'potassium', 'haemoglobin', 'packed_cell_volume', 'white_blood_cell_count', 'red_blood_cell_count',
 'hypertension', 'diabetes_mellitus', 'coronary_artery_disease', 'appetite', 'peda_edema',
 'aanemia', 'class']
```

| In [6]: | <code>df.head()</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                |                  |                |                  |                 |          |                 |            |                      |            |                      |            |                  |        |     |   |      |      |       |     |     |     |        |            |            |       |      |     |     |  |   |     |      |       |     |     |     |        |            |            |     |      |     |     |  |   |      |      |       |     |     |        |        |            |            |       |      |     |     |  |   |      |      |       |     |     |        |          |         |            |       |      |     |       |  |   |      |      |       |     |     |        |        |            |            |       |      |     |     |  |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|------------------|----------------|------------------|-----------------|----------|-----------------|------------|----------------------|------------|----------------------|------------|------------------|--------|-----|---|------|------|-------|-----|-----|-----|--------|------------|------------|-------|------|-----|-----|--|---|-----|------|-------|-----|-----|-----|--------|------------|------------|-----|------|-----|-----|--|---|------|------|-------|-----|-----|--------|--------|------------|------------|-------|------|-----|-----|--|---|------|------|-------|-----|-----|--------|----------|---------|------------|-------|------|-----|-------|--|---|------|------|-------|-----|-----|--------|--------|------------|------------|-------|------|-----|-----|--|
| Out[6]: | <table border="1"> <thead> <tr> <th></th><th>age</th><th>blood_pressure</th><th>specific_gravity</th><th>albumin</th><th>sugar</th><th>red_blood_cells</th><th>pus_cell</th><th>pus_cell_clumps</th><th>bacteria</th><th>blood_glucose_random</th><th>blood_urea</th><th>serum_creatinine</th><th>sodium</th><th>pot</th></tr> </thead> <tbody> <tr><td>0</td><td>48.0</td><td>80.0</td><td>1.020</td><td>1.0</td><td>0.0</td><td>NaN</td><td>normal</td><td>notpresent</td><td>notpresent</td><td>121.0</td><td>36.0</td><td>1.2</td><td>NaN</td><td></td></tr> <tr><td>1</td><td>7.0</td><td>50.0</td><td>1.020</td><td>4.0</td><td>0.0</td><td>NaN</td><td>normal</td><td>notpresent</td><td>notpresent</td><td>NaN</td><td>18.0</td><td>0.8</td><td>NaN</td><td></td></tr> <tr><td>2</td><td>62.0</td><td>80.0</td><td>1.010</td><td>2.0</td><td>3.0</td><td>normal</td><td>normal</td><td>notpresent</td><td>notpresent</td><td>423.0</td><td>53.0</td><td>1.8</td><td>NaN</td><td></td></tr> <tr><td>3</td><td>48.0</td><td>70.0</td><td>1.005</td><td>4.0</td><td>0.0</td><td>normal</td><td>abnormal</td><td>present</td><td>notpresent</td><td>117.0</td><td>56.0</td><td>3.8</td><td>111.0</td><td></td></tr> <tr><td>4</td><td>51.0</td><td>80.0</td><td>1.010</td><td>2.0</td><td>0.0</td><td>normal</td><td>normal</td><td>notpresent</td><td>notpresent</td><td>106.0</td><td>26.0</td><td>1.4</td><td>NaN</td><td></td></tr> </tbody> </table> |                | age              | blood_pressure | specific_gravity | albumin         | sugar    | red_blood_cells | pus_cell   | pus_cell_clumps      | bacteria   | blood_glucose_random | blood_urea | serum_creatinine | sodium | pot | 0 | 48.0 | 80.0 | 1.020 | 1.0 | 0.0 | NaN | normal | notpresent | notpresent | 121.0 | 36.0 | 1.2 | NaN |  | 1 | 7.0 | 50.0 | 1.020 | 4.0 | 0.0 | NaN | normal | notpresent | notpresent | NaN | 18.0 | 0.8 | NaN |  | 2 | 62.0 | 80.0 | 1.010 | 2.0 | 3.0 | normal | normal | notpresent | notpresent | 423.0 | 53.0 | 1.8 | NaN |  | 3 | 48.0 | 70.0 | 1.005 | 4.0 | 0.0 | normal | abnormal | present | notpresent | 117.0 | 56.0 | 3.8 | 111.0 |  | 4 | 51.0 | 80.0 | 1.010 | 2.0 | 0.0 | normal | normal | notpresent | notpresent | 106.0 | 26.0 | 1.4 | NaN |  |
|         | age                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | blood_pressure | specific_gravity | albumin        | sugar            | red_blood_cells | pus_cell | pus_cell_clumps | bacteria   | blood_glucose_random | blood_urea | serum_creatinine     | sodium     | pot              |        |     |   |      |      |       |     |     |     |        |            |            |       |      |     |     |  |   |     |      |       |     |     |     |        |            |            |     |      |     |     |  |   |      |      |       |     |     |        |        |            |            |       |      |     |     |  |   |      |      |       |     |     |        |          |         |            |       |      |     |       |  |   |      |      |       |     |     |        |        |            |            |       |      |     |     |  |
| 0       | 48.0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 80.0           | 1.020            | 1.0            | 0.0              | NaN             | normal   | notpresent      | notpresent | 121.0                | 36.0       | 1.2                  | NaN        |                  |        |     |   |      |      |       |     |     |     |        |            |            |       |      |     |     |  |   |     |      |       |     |     |     |        |            |            |     |      |     |     |  |   |      |      |       |     |     |        |        |            |            |       |      |     |     |  |   |      |      |       |     |     |        |          |         |            |       |      |     |       |  |   |      |      |       |     |     |        |        |            |            |       |      |     |     |  |
| 1       | 7.0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 50.0           | 1.020            | 4.0            | 0.0              | NaN             | normal   | notpresent      | notpresent | NaN                  | 18.0       | 0.8                  | NaN        |                  |        |     |   |      |      |       |     |     |     |        |            |            |       |      |     |     |  |   |     |      |       |     |     |     |        |            |            |     |      |     |     |  |   |      |      |       |     |     |        |        |            |            |       |      |     |     |  |   |      |      |       |     |     |        |          |         |            |       |      |     |       |  |   |      |      |       |     |     |        |        |            |            |       |      |     |     |  |
| 2       | 62.0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 80.0           | 1.010            | 2.0            | 3.0              | normal          | normal   | notpresent      | notpresent | 423.0                | 53.0       | 1.8                  | NaN        |                  |        |     |   |      |      |       |     |     |     |        |            |            |       |      |     |     |  |   |     |      |       |     |     |     |        |            |            |     |      |     |     |  |   |      |      |       |     |     |        |        |            |            |       |      |     |     |  |   |      |      |       |     |     |        |          |         |            |       |      |     |       |  |   |      |      |       |     |     |        |        |            |            |       |      |     |     |  |
| 3       | 48.0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 70.0           | 1.005            | 4.0            | 0.0              | normal          | abnormal | present         | notpresent | 117.0                | 56.0       | 3.8                  | 111.0      |                  |        |     |   |      |      |       |     |     |     |        |            |            |       |      |     |     |  |   |     |      |       |     |     |     |        |            |            |     |      |     |     |  |   |      |      |       |     |     |        |        |            |            |       |      |     |     |  |   |      |      |       |     |     |        |          |         |            |       |      |     |       |  |   |      |      |       |     |     |        |        |            |            |       |      |     |     |  |
| 4       | 51.0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 80.0           | 1.010            | 2.0            | 0.0              | normal          | normal   | notpresent      | notpresent | 106.0                | 26.0       | 1.4                  | NaN        |                  |        |     |   |      |      |       |     |     |     |        |            |            |       |      |     |     |  |   |     |      |       |     |     |     |        |            |            |     |      |     |     |  |   |      |      |       |     |     |        |        |            |            |       |      |     |     |  |   |      |      |       |     |     |        |          |         |            |       |      |     |       |  |   |      |      |       |     |     |        |        |            |            |       |      |     |     |  |

| In [7]: | <code>df.describe()</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                |                  |                |                  |                      |            |                      |            |                  |             |           |             |       |            |            |            |            |            |            |            |            |            |            |            |      |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |           |           |          |           |          |          |     |          |           |          |          |          |           |          |          |          |          |          |     |           |           |          |          |          |           |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |            |          |          |          |            |            |           |            |           |           |
|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|------------------|----------------|------------------|----------------------|------------|----------------------|------------|------------------|-------------|-----------|-------------|-------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------|-----------|-----------|----------|----------|----------|------------|-----------|----------|------------|----------|-----------|-----|-----------|-----------|----------|----------|----------|-----------|-----------|----------|-----------|----------|----------|-----|----------|-----------|----------|----------|----------|-----------|----------|----------|----------|----------|----------|-----|-----------|-----------|----------|----------|----------|-----------|-----------|----------|------------|----------|-----------|-----|-----------|-----------|----------|----------|----------|------------|-----------|----------|------------|----------|-----------|-----|-----------|-----------|----------|----------|----------|------------|-----------|----------|------------|----------|-----------|-----|-----------|------------|----------|----------|----------|------------|------------|-----------|------------|-----------|-----------|
| Out[7]: | <table border="1"> <thead> <tr> <th></th><th>age</th><th>blood_pressure</th><th>specific_gravity</th><th>albumin</th><th>sugar</th><th>blood_glucose_random</th><th>blood_urea</th><th>serum_creatinine</th><th>sodium</th><th>potassium</th><th>haemoglobin</th></tr> </thead> <tbody> <tr><td>count</td><td>391.000000</td><td>388.000000</td><td>353.000000</td><td>354.000000</td><td>351.000000</td><td>356.000000</td><td>381.000000</td><td>383.000000</td><td>313.000000</td><td>312.000000</td><td>348.000000</td></tr> <tr><td>mean</td><td>51.483376</td><td>76.469072</td><td>1.017408</td><td>1.016949</td><td>0.450142</td><td>148.036517</td><td>57.425722</td><td>3.072454</td><td>137.528754</td><td>4.627244</td><td>12.526437</td></tr> <tr><td>std</td><td>17.169714</td><td>13.683637</td><td>0.005717</td><td>1.352679</td><td>1.099191</td><td>79.281714</td><td>50.503006</td><td>5.741126</td><td>10.408752</td><td>3.193904</td><td>2.912587</td></tr> <tr><td>min</td><td>2.000000</td><td>50.000000</td><td>1.005000</td><td>0.000000</td><td>0.000000</td><td>22.000000</td><td>1.500000</td><td>0.400000</td><td>4.500000</td><td>2.500000</td><td>3.100000</td></tr> <tr><td>25%</td><td>42.000000</td><td>70.000000</td><td>1.010000</td><td>0.000000</td><td>0.000000</td><td>99.000000</td><td>27.000000</td><td>0.900000</td><td>135.000000</td><td>3.800000</td><td>10.300000</td></tr> <tr><td>50%</td><td>55.000000</td><td>80.000000</td><td>1.020000</td><td>0.000000</td><td>0.000000</td><td>121.000000</td><td>42.000000</td><td>1.300000</td><td>138.000000</td><td>4.400000</td><td>12.650000</td></tr> <tr><td>75%</td><td>64.500000</td><td>80.000000</td><td>1.020000</td><td>2.000000</td><td>0.000000</td><td>163.000000</td><td>66.000000</td><td>2.800000</td><td>142.000000</td><td>4.900000</td><td>15.000000</td></tr> <tr><td>max</td><td>90.000000</td><td>180.000000</td><td>1.025000</td><td>5.000000</td><td>5.000000</td><td>490.000000</td><td>391.000000</td><td>76.000000</td><td>163.000000</td><td>47.000000</td><td>17.800000</td></tr> </tbody> </table> |                | age              | blood_pressure | specific_gravity | albumin              | sugar      | blood_glucose_random | blood_urea | serum_creatinine | sodium      | potassium | haemoglobin | count | 391.000000 | 388.000000 | 353.000000 | 354.000000 | 351.000000 | 356.000000 | 381.000000 | 383.000000 | 313.000000 | 312.000000 | 348.000000 | mean | 51.483376 | 76.469072 | 1.017408 | 1.016949 | 0.450142 | 148.036517 | 57.425722 | 3.072454 | 137.528754 | 4.627244 | 12.526437 | std | 17.169714 | 13.683637 | 0.005717 | 1.352679 | 1.099191 | 79.281714 | 50.503006 | 5.741126 | 10.408752 | 3.193904 | 2.912587 | min | 2.000000 | 50.000000 | 1.005000 | 0.000000 | 0.000000 | 22.000000 | 1.500000 | 0.400000 | 4.500000 | 2.500000 | 3.100000 | 25% | 42.000000 | 70.000000 | 1.010000 | 0.000000 | 0.000000 | 99.000000 | 27.000000 | 0.900000 | 135.000000 | 3.800000 | 10.300000 | 50% | 55.000000 | 80.000000 | 1.020000 | 0.000000 | 0.000000 | 121.000000 | 42.000000 | 1.300000 | 138.000000 | 4.400000 | 12.650000 | 75% | 64.500000 | 80.000000 | 1.020000 | 2.000000 | 0.000000 | 163.000000 | 66.000000 | 2.800000 | 142.000000 | 4.900000 | 15.000000 | max | 90.000000 | 180.000000 | 1.025000 | 5.000000 | 5.000000 | 490.000000 | 391.000000 | 76.000000 | 163.000000 | 47.000000 | 17.800000 |
|         | age                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | blood_pressure | specific_gravity | albumin        | sugar            | blood_glucose_random | blood_urea | serum_creatinine     | sodium     | potassium        | haemoglobin |           |             |       |            |            |            |            |            |            |            |            |            |            |            |      |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |           |           |          |           |          |          |     |          |           |          |          |          |           |          |          |          |          |          |     |           |           |          |          |          |           |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |            |          |          |          |            |            |           |            |           |           |
| count   | 391.000000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 388.000000     | 353.000000       | 354.000000     | 351.000000       | 356.000000           | 381.000000 | 383.000000           | 313.000000 | 312.000000       | 348.000000  |           |             |       |            |            |            |            |            |            |            |            |            |            |            |      |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |           |           |          |           |          |          |     |          |           |          |          |          |           |          |          |          |          |          |     |           |           |          |          |          |           |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |            |          |          |          |            |            |           |            |           |           |
| mean    | 51.483376                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 76.469072      | 1.017408         | 1.016949       | 0.450142         | 148.036517           | 57.425722  | 3.072454             | 137.528754 | 4.627244         | 12.526437   |           |             |       |            |            |            |            |            |            |            |            |            |            |            |      |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |           |           |          |           |          |          |     |          |           |          |          |          |           |          |          |          |          |          |     |           |           |          |          |          |           |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |            |          |          |          |            |            |           |            |           |           |
| std     | 17.169714                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 13.683637      | 0.005717         | 1.352679       | 1.099191         | 79.281714            | 50.503006  | 5.741126             | 10.408752  | 3.193904         | 2.912587    |           |             |       |            |            |            |            |            |            |            |            |            |            |            |      |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |           |           |          |           |          |          |     |          |           |          |          |          |           |          |          |          |          |          |     |           |           |          |          |          |           |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |            |          |          |          |            |            |           |            |           |           |
| min     | 2.000000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 50.000000      | 1.005000         | 0.000000       | 0.000000         | 22.000000            | 1.500000   | 0.400000             | 4.500000   | 2.500000         | 3.100000    |           |             |       |            |            |            |            |            |            |            |            |            |            |            |      |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |           |           |          |           |          |          |     |          |           |          |          |          |           |          |          |          |          |          |     |           |           |          |          |          |           |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |            |          |          |          |            |            |           |            |           |           |
| 25%     | 42.000000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 70.000000      | 1.010000         | 0.000000       | 0.000000         | 99.000000            | 27.000000  | 0.900000             | 135.000000 | 3.800000         | 10.300000   |           |             |       |            |            |            |            |            |            |            |            |            |            |            |      |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |           |           |          |           |          |          |     |          |           |          |          |          |           |          |          |          |          |          |     |           |           |          |          |          |           |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |            |          |          |          |            |            |           |            |           |           |
| 50%     | 55.000000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 80.000000      | 1.020000         | 0.000000       | 0.000000         | 121.000000           | 42.000000  | 1.300000             | 138.000000 | 4.400000         | 12.650000   |           |             |       |            |            |            |            |            |            |            |            |            |            |            |      |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |           |           |          |           |          |          |     |          |           |          |          |          |           |          |          |          |          |          |     |           |           |          |          |          |           |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |            |          |          |          |            |            |           |            |           |           |
| 75%     | 64.500000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 80.000000      | 1.020000         | 2.000000       | 0.000000         | 163.000000           | 66.000000  | 2.800000             | 142.000000 | 4.900000         | 15.000000   |           |             |       |            |            |            |            |            |            |            |            |            |            |            |      |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |           |           |          |           |          |          |     |          |           |          |          |          |           |          |          |          |          |          |     |           |           |          |          |          |           |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |            |          |          |          |            |            |           |            |           |           |
| max     | 90.000000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 180.000000     | 1.025000         | 5.000000       | 5.000000         | 490.000000           | 391.000000 | 76.000000            | 163.000000 | 47.000000        | 17.800000   |           |             |       |            |            |            |            |            |            |            |            |            |            |            |      |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |           |           |          |           |          |          |     |          |           |          |          |          |           |          |          |          |          |          |     |           |           |          |          |          |           |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |           |          |          |          |            |           |          |            |          |           |     |           |            |          |          |          |            |            |           |            |           |           |

| In [8]: | <code>df.info()</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                |                  |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|------------------|----------------|-------|---|-----|-----|------------------|---|----------------|-----|------------------|---|------------------|-----|------------------|---|---------|-----|------------------|---|-------|-----|------------------|---|-----------------|-----|-----------------|---|----------|-----|-----------------|---|-----------------|-----|-----------------|---|----------|-----|-----------------|---|----------------------|-----|------------------|----|------------|-----|------------------|----|------------------|-----|------------------|----|--------|-----|------------------|----|-----------|-----|------------------|----|-------------|-----|------------------|----|--------------------|-----|-----------------|----|------------------------|-----|-----------------|----|----------------------|-----|-----------------|----|--------------|-----|-----------------|----|-------------------|-----|-----------------|----|-------------------------|-----|-----------------|----|----------|-----|-----------------|----|------------|-----|-----------------|----|---------|-----|-----------------|----|-------|-----|-----------------|
|         | <p>RangeIndex: 400 entries, 0 to 399<br/> Data columns (total 25 columns):</p> <table border="1"> <thead> <tr> <th>#</th><th>Column</th><th>Non-Null Count</th><th>Dtype</th></tr> </thead> <tbody> <tr><td>0</td><td>age</td><td>391</td><td>non-null float64</td></tr> <tr><td>1</td><td>blood_pressure</td><td>388</td><td>non-null float64</td></tr> <tr><td>2</td><td>specific_gravity</td><td>353</td><td>non-null float64</td></tr> <tr><td>3</td><td>albumin</td><td>354</td><td>non-null float64</td></tr> <tr><td>4</td><td>sugar</td><td>351</td><td>non-null float64</td></tr> <tr><td>5</td><td>red_blood_cells</td><td>248</td><td>non-null object</td></tr> <tr><td>6</td><td>pus_cell</td><td>335</td><td>non-null object</td></tr> <tr><td>7</td><td>pus_cell_clumps</td><td>396</td><td>non-null object</td></tr> <tr><td>8</td><td>bacteria</td><td>396</td><td>non-null object</td></tr> <tr><td>9</td><td>blood_glucose_random</td><td>356</td><td>non-null float64</td></tr> <tr><td>10</td><td>blood_urea</td><td>381</td><td>non-null float64</td></tr> <tr><td>11</td><td>serum_creatinine</td><td>383</td><td>non-null float64</td></tr> <tr><td>12</td><td>sodium</td><td>313</td><td>non-null float64</td></tr> <tr><td>13</td><td>potassium</td><td>312</td><td>non-null float64</td></tr> <tr><td>14</td><td>haemoglobin</td><td>348</td><td>non-null float64</td></tr> <tr><td>15</td><td>packed_cell_volume</td><td>330</td><td>non-null object</td></tr> <tr><td>16</td><td>white_blood_cell_count</td><td>295</td><td>non-null object</td></tr> <tr><td>17</td><td>red_blood_cell_count</td><td>270</td><td>non-null object</td></tr> <tr><td>18</td><td>hypertension</td><td>398</td><td>non-null object</td></tr> <tr><td>19</td><td>diabetes_mellitus</td><td>398</td><td>non-null object</td></tr> <tr><td>20</td><td>coronary_artery_disease</td><td>398</td><td>non-null object</td></tr> <tr><td>21</td><td>appetite</td><td>399</td><td>non-null object</td></tr> <tr><td>22</td><td>peda_edema</td><td>399</td><td>non-null object</td></tr> <tr><td>23</td><td>aanemia</td><td>399</td><td>non-null object</td></tr> <tr><td>24</td><td>class</td><td>400</td><td>non-null object</td></tr> </tbody> </table> <p>dtypes: float64(11), object(14)<br/> memory usage: 78.2+ KB</p> | #              | Column           | Non-Null Count | Dtype | 0 | age | 391 | non-null float64 | 1 | blood_pressure | 388 | non-null float64 | 2 | specific_gravity | 353 | non-null float64 | 3 | albumin | 354 | non-null float64 | 4 | sugar | 351 | non-null float64 | 5 | red_blood_cells | 248 | non-null object | 6 | pus_cell | 335 | non-null object | 7 | pus_cell_clumps | 396 | non-null object | 8 | bacteria | 396 | non-null object | 9 | blood_glucose_random | 356 | non-null float64 | 10 | blood_urea | 381 | non-null float64 | 11 | serum_creatinine | 383 | non-null float64 | 12 | sodium | 313 | non-null float64 | 13 | potassium | 312 | non-null float64 | 14 | haemoglobin | 348 | non-null float64 | 15 | packed_cell_volume | 330 | non-null object | 16 | white_blood_cell_count | 295 | non-null object | 17 | red_blood_cell_count | 270 | non-null object | 18 | hypertension | 398 | non-null object | 19 | diabetes_mellitus | 398 | non-null object | 20 | coronary_artery_disease | 398 | non-null object | 21 | appetite | 399 | non-null object | 22 | peda_edema | 399 | non-null object | 23 | aanemia | 399 | non-null object | 24 | class | 400 | non-null object |
| #       | Column                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Non-Null Count | Dtype            |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 0       | age                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 391            | non-null float64 |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 1       | blood_pressure                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 388            | non-null float64 |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 2       | specific_gravity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 353            | non-null float64 |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 3       | albumin                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 354            | non-null float64 |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 4       | sugar                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 351            | non-null float64 |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 5       | red_blood_cells                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 248            | non-null object  |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 6       | pus_cell                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 335            | non-null object  |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 7       | pus_cell_clumps                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 396            | non-null object  |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 8       | bacteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 396            | non-null object  |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 9       | blood_glucose_random                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 356            | non-null float64 |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 10      | blood_urea                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 381            | non-null float64 |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 11      | serum_creatinine                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 383            | non-null float64 |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 12      | sodium                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 313            | non-null float64 |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 13      | potassium                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 312            | non-null float64 |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 14      | haemoglobin                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 348            | non-null float64 |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 15      | packed_cell_volume                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 330            | non-null object  |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 16      | white_blood_cell_count                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 295            | non-null object  |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 17      | red_blood_cell_count                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 270            | non-null object  |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 18      | hypertension                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 398            | non-null object  |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 19      | diabetes_mellitus                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 398            | non-null object  |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 20      | coronary_artery_disease                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 398            | non-null object  |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 21      | appetite                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 399            | non-null object  |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 22      | peda_edema                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 399            | non-null object  |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 23      | aanemia                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 399            | non-null object  |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |
| 24      | class                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 400            | non-null object  |                |       |   |     |     |                  |   |                |     |                  |   |                  |     |                  |   |         |     |                  |   |       |     |                  |   |                 |     |                 |   |          |     |                 |   |                 |     |                 |   |          |     |                 |   |                      |     |                  |    |            |     |                  |    |                  |     |                  |    |        |     |                  |    |           |     |                  |    |             |     |                  |    |                    |     |                 |    |                        |     |                 |    |                      |     |                 |    |              |     |                 |    |                   |     |                 |    |                         |     |                 |    |          |     |                 |    |            |     |                 |    |         |     |                 |    |       |     |                 |

|         |                                                                                                                                                                                                                                                                                    |
|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| In [9]: | # converting necessary columns to numerical type                                                                                                                                                                                                                                   |
|         | <pre>df['packed_cell_volume'] = pd.to_numeric(df['packed_cell_volume'], errors='coerce') df['white_blood_cell_count'] = pd.to_numeric(df['white_blood_cell_count'], errors='coerce') df['red_blood_cell_count'] = pd.to_numeric(df['red_blood_cell_count'], errors='coerce')</pre> |

In [10]:

```
df.info()

RangeIndex: 400 entries, 0 to 399
Data columns (total 25 columns):
 # Column Non-Null Count Dtype
 --- -- -- --
 0 age 391 non-null float64
 1 blood_pressure 388 non-null float64
 2 specific_gravity 353 non-null float64
 3 albumin 354 non-null float64
 4 sugar 351 non-null float64
 5 red_blood_cells 248 non-null object
 6 pus_cell 335 non-null object
 7 pus_cell_clumps 396 non-null object
 8 bacteria 396 non-null object
 9 blood_glucose_random 356 non-null float64
 10 blood_urea 381 non-null float64
 11 serum_creatinine 383 non-null float64
 12 sodium 313 non-null float64
 13 potassium 312 non-null float64
 14 haemoglobin 348 non-null float64
 15 packed_cell_volume 329 non-null float64
 16 white_blood_cell_count 294 non-null float64
 17 red_blood_cell_count 269 non-null float64
 18 hypertension 398 non-null object
 19 diabetes_mellitus 398 non-null object
 20 coronary_artery_disease 398 non-null object
 21 appetite 399 non-null object
 22 peda_edema 399 non-null object
 23 anaemia 399 non-null object
 24 class 400 non-null object
dtypes: float64(14), object(11)
memory usage: 78.2+ KB
```

In [11]:

```
Extracting categorical and numerical columns

cat_cols = [col for col in df.columns if df[col].dtype == 'object']
num_cols = [col for col in df.columns if df[col].dtype != 'object']
```

In [12]:

```
Looking at unique values in categorical columns

for col in cat_cols:
 print(f"{col} has {df[col].unique()} values\n")

red_blood_cells has [nan 'normal' 'abnormal'] values
pus_cell has ['normal' 'abnormal' nan] values
pus_cell_clumps has ['notpresent' 'present' nan] values
bacteria has ['notpresent' 'present' nan] values
hypertension has ['yes' 'no' nan] values
diabetes_mellitus has ['yes' 'no' 'yes' '\tno' '\tys' nan] values
coronary_artery_disease has ['no' 'yes' '\tno' nan] values
appetite has ['good' 'poor' nan] values
peda_edema has ['no' 'yes' nan] values
anaemia has ['no' 'yes' nan] values
class has ['ckd' 'ckd\t' 'notckd'] values
```

## Removing Ambiguity

```
In [13]: # replace incorrect values
df['diabetes_mellitus'].replace(to_replace = {'\tno':'no','\tyes':'yes',' yes':'yes'},inplace=True)
df['coronary_artery_disease'] = df['coronary_artery_disease'].replace(to_replace = '\tno', value='no')
df['class'] = df['class'].replace(to_replace = {'ckd\t': 'ckd', 'not ckd\t': 'not ckd'})
```

```
In [14]: df['class'] = df['class'].map({0: 'no', 1: 'yes'})
df['class'] = pd.to_numeric(df['class'], errors='coerce')
```

```
In [15]: cols = ['diabetes_mellitus', 'coronary_artery_disease', 'class']

for col in cols:
 print(f"\n{col} has [{df[col].unique()}] values\n")

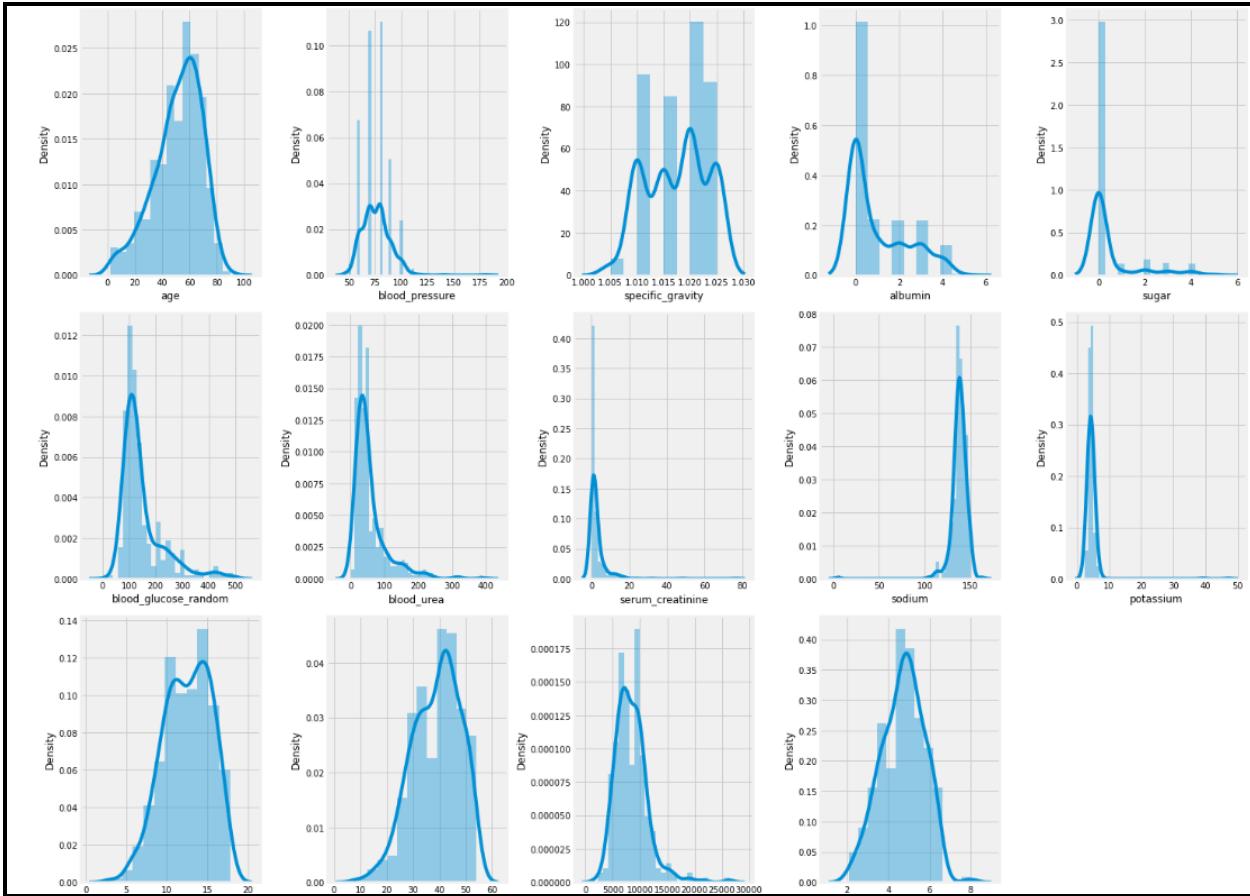
diabetes_mellitus has ['yes' 'no' nan] values
coronary_artery_disease has ['no' 'yes' nan] values
class has [0 1] values
```

```
In [16]: # checking numerical features distribution
plt.figure(figsize = (20, 15))
plotnumber = 1

for column in num_cols:
 if plotnumber <= 14:
 ax = plt.subplot(3, 5, plotnumber)
 sns.distplot(df[column])
 plt.xlabel(column)

 plotnumber += 1

plt.tight_layout()
plt.show()
```



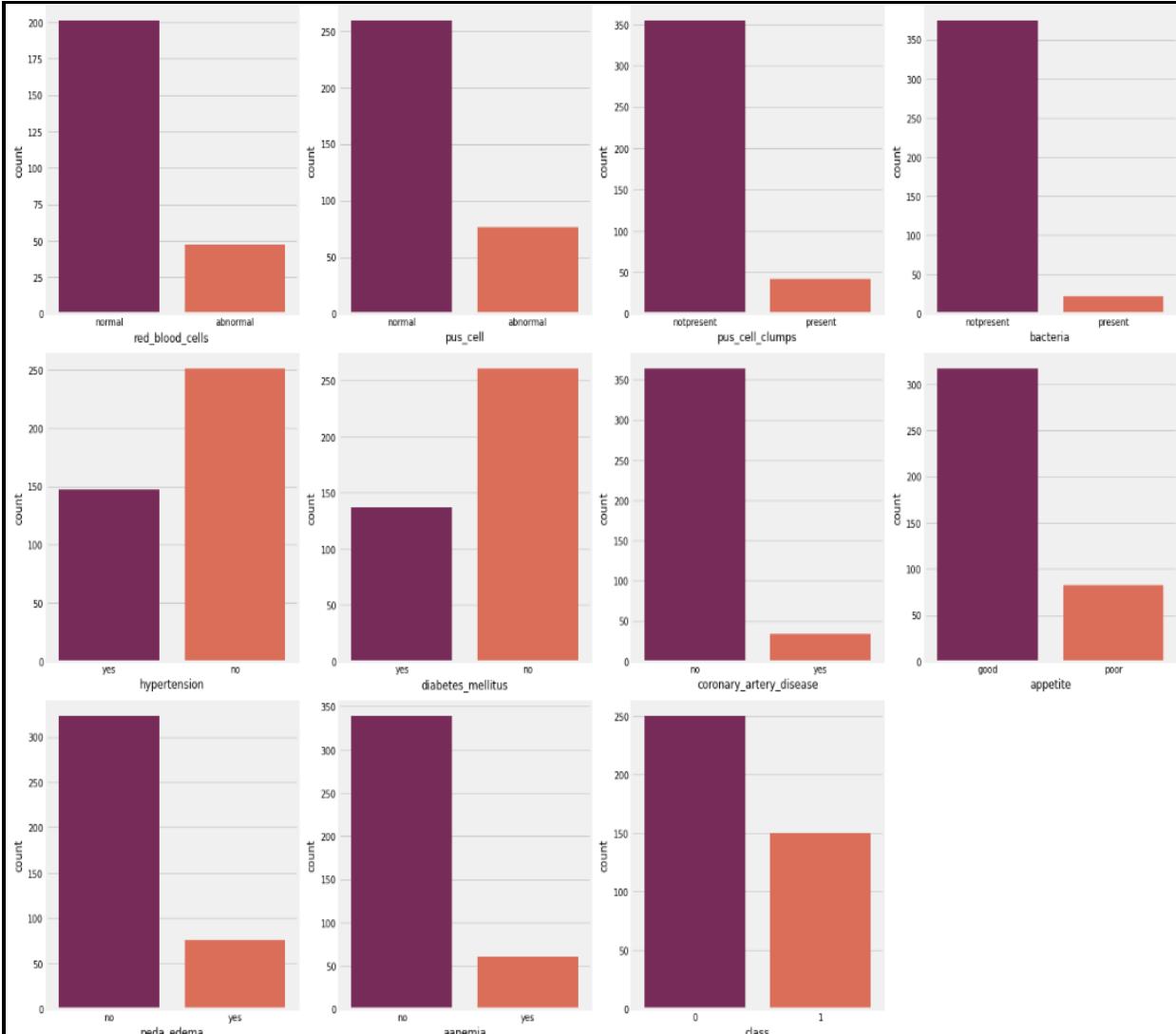
In [17]: # Looking at categorical columns

```
plt.figure(figsize = (20, 15))
plotnumber = 1

for column in cat_cols:
 if plotnumber <= 11:
 ax = plt.subplot(3, 4, plotnumber)
 sns.countplot(df[column], palette = 'rocket')
 plt.xlabel(column)

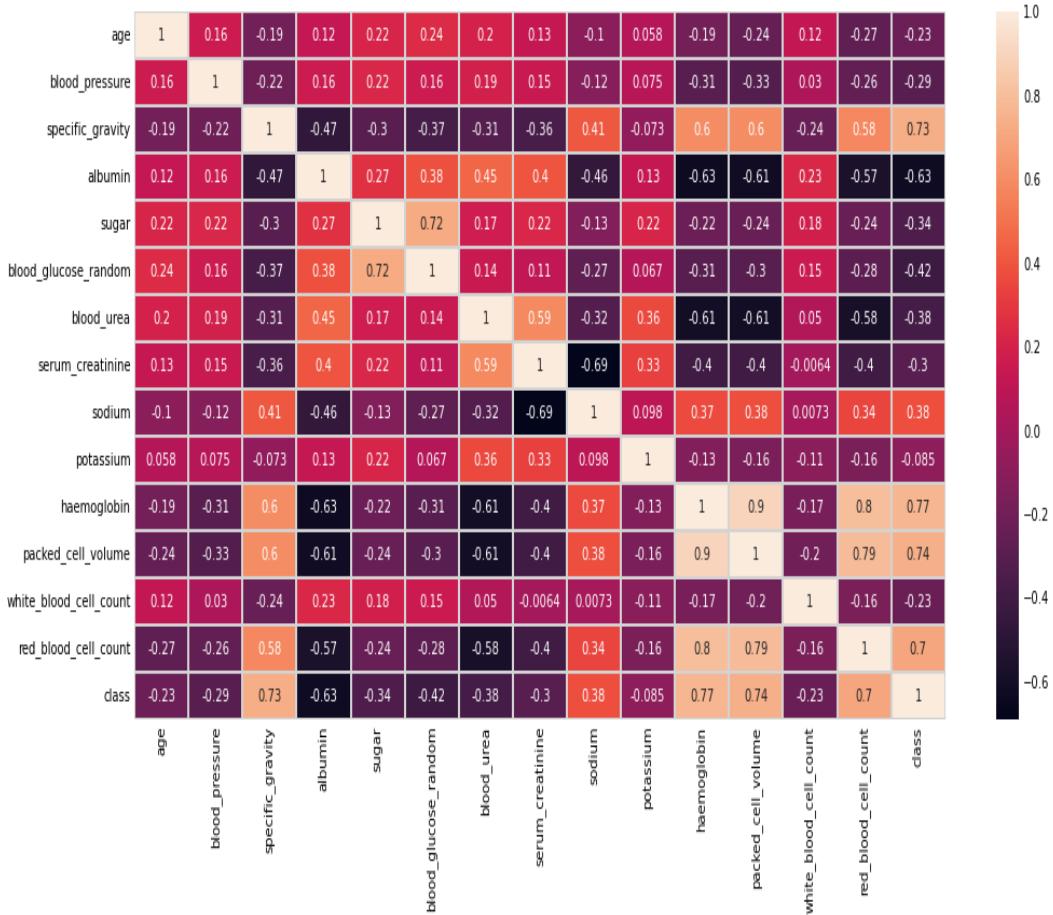
 plotnumber += 1

plt.tight_layout()
plt.show()
```



```
In [18]: # heatmap of data
plt.figure(figsize = (15, 8))

sns.heatmap(df.corr(), annot = True, linewidths = 2, linecolor = 'lightgrey')
plt.show()
```



```
In [19]: df.columns
```

```
Out[19]: Index(['age', 'blood_pressure', 'specific_gravity', 'albumin', 'sugar',
 'red_blood_cells', 'pus_cell', 'pus_cell_clumps', 'bacteria',
 'blood_glucose_random', 'blood_urea', 'serum_creatinine', 'sodium',
 'potassium', 'haemoglobin', 'packed_cell_volume',
 'white_blood_cell_count', 'red_blood_cell_count', 'hypertension',
 'diabetes_mellitus', 'coronary_artery_disease', 'appetite',
 'pedo_edema', 'aanemia', 'class'],
 dtype='object')
```

## Data Analysis

```
In [20]: # defining functions to create plot

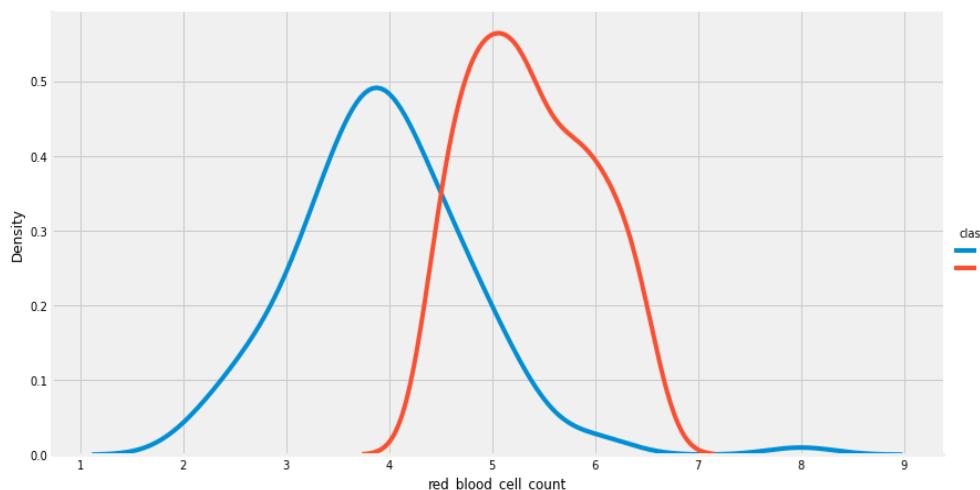
def violin(col):
 fig = px.violin(df, y=col, x="class", color="class", box=True, template = 'plotly_dark')
 return fig.show()

def kde(col):
 grid = sns.FacetGrid(df, hue="class", height = 6, aspect=2)
 grid.map(sns.kdeplot, col)
 grid.add_legend()

def scatter(col1, col2):
 fig = px.scatter(df, x=col1, y=col2, color="class", template = 'plotly_dark')
 return fig.show()
```

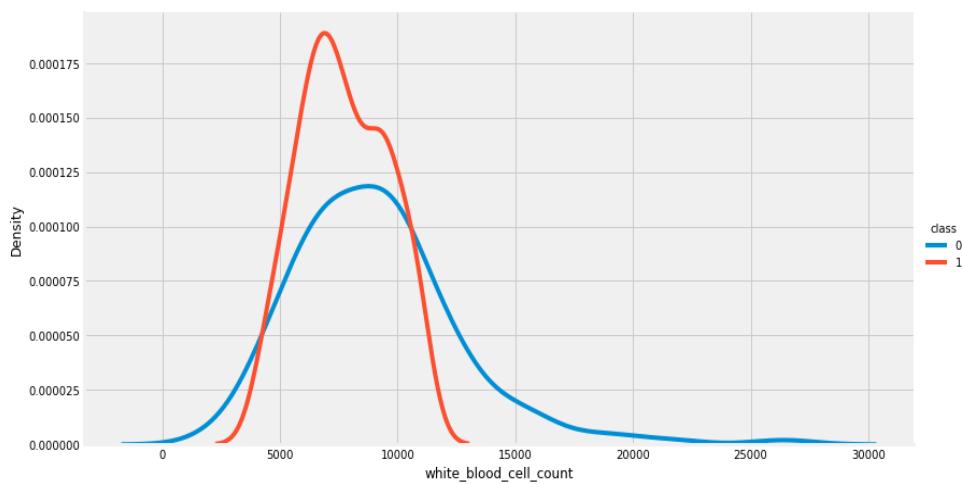
```
In [21]: violin('red_blood_cell_count')
```

```
In [22]: kde('red_blood_cell_count')
```



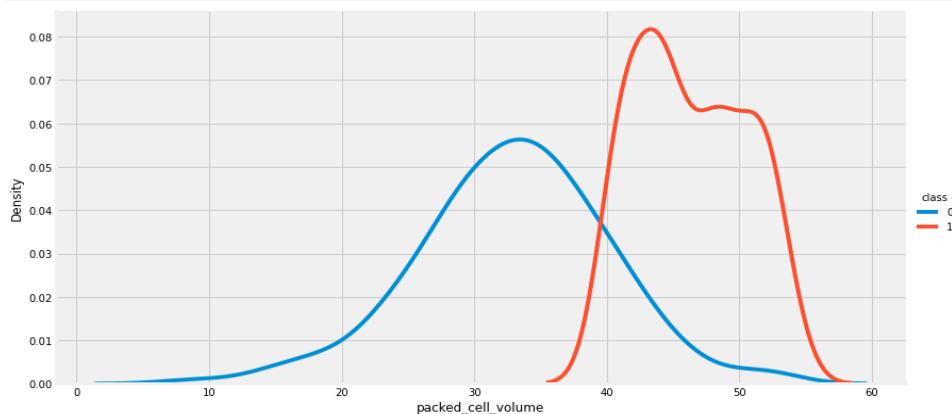
```
In [23]: violin('white_blood_cell_count')
```

```
In [24]: kde('white_blood_cell_count')
```



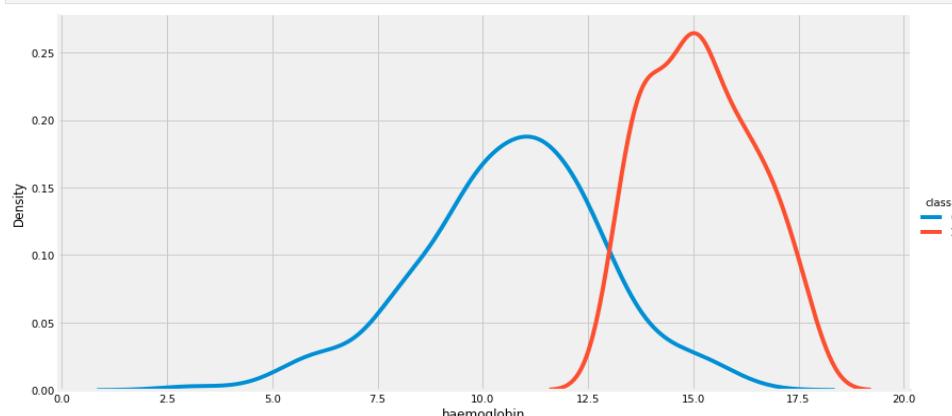
```
In [25]: violin('packed_cell_volume')
```

```
In [26]: kde('packed_cell_volume')
```



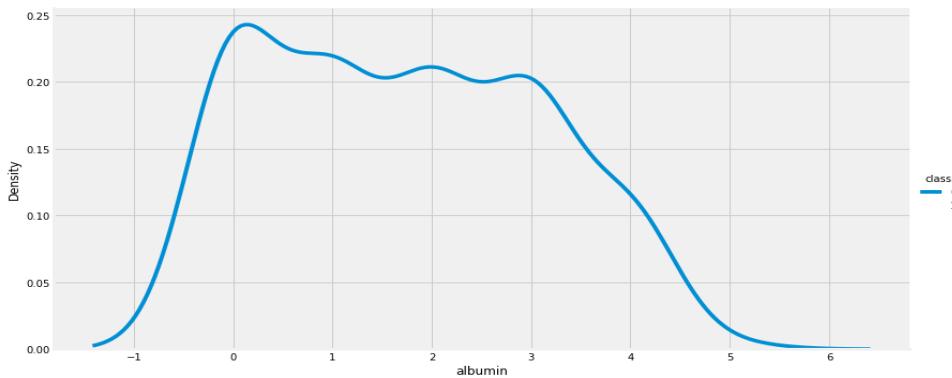
```
In [27]: violin('haemoglobin')
```

```
In [28]: kde('haemoglobin')
```

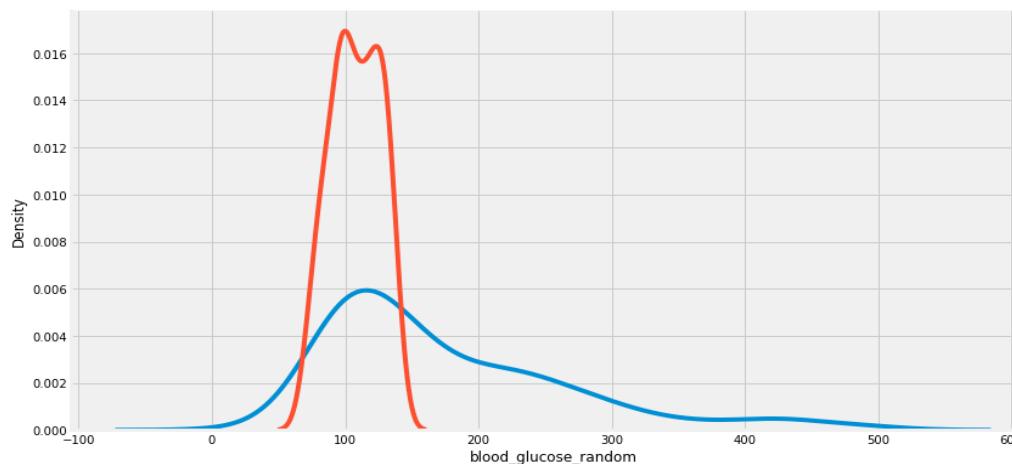


```
In [29]: violin('albumin')
```

```
In [30]: kde('albumin')
```

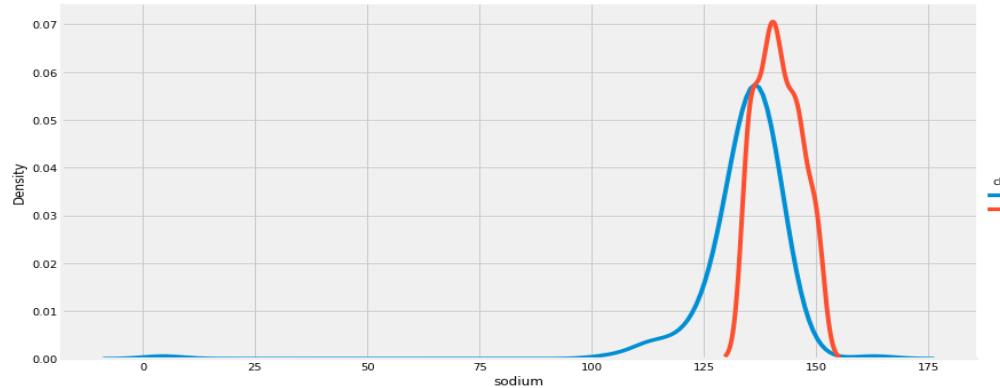


```
In [32]: kde('blood_glucose_random')
```



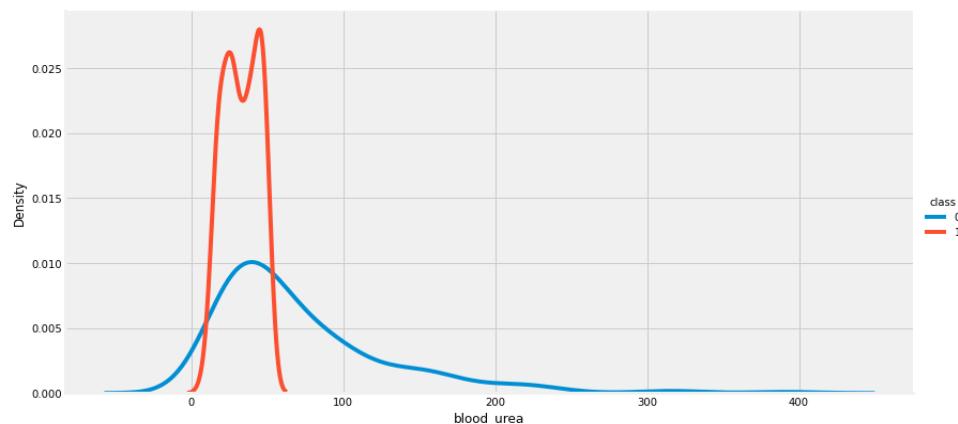
```
In [33]: violin('sodium')
```

```
In [34]: kde('sodium')
```

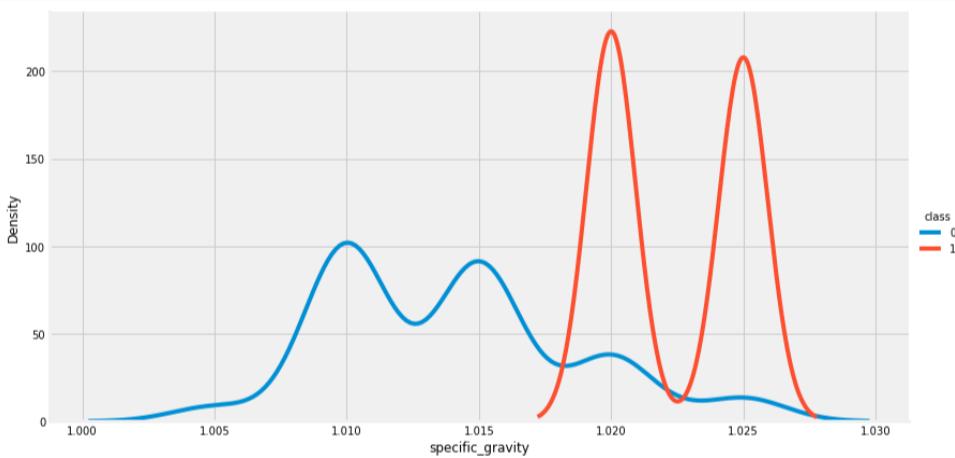


```
In [35]: violin('blood_urea')
```

```
In [36]: kde('blood_urea')
```



```
In [38]: kde('specific_gravity')
```



```
In [40]: scatter('red_blood_cell_count', 'packed_cell_volume')
```

```
In [41]: scatter('red_blood_cell_count', 'albumin')
```

```
In [42]: scatter('sugar', 'blood_glucose_random')
```

```
In [43]: scatter('packed_cell_volume','blood_urea')
```

```
In [44]: px.bar(df, x="specific_gravity", y="packed_cell_volume", color='class', barmode='group', template = 'plotly_dark', height = 400)
```

```
In [45]: px.bar(df, x="specific_gravity", y="albumin", color='class', barmode='group', template = 'plotly_dark', height = 400)
```

```
In [46]: px.bar(df, x="blood_pressure", y="packed_cell_volume", color='class', barmode='group', template = 'plotly_dark', height = 400)
```

```
In [47]: px.bar(df, x="blood_pressure", y="haemoglobin", color='class', barmode='group', template = 'plotly_dark', height = 400)
```

```
In [48]: # checking for null values
df.isna().sum().sort_values(ascending = False)
```

```
Out[48]: red_blood_cells 152
red_blood_cell_count 131
white_blood_cell_count 106
potassium 88
sodium 87
packed_cell_volume 71
pus_cell 65
haemoglobin 52
sugar 49
specific_gravity 47
albumin 46
blood_glucose_random 44
blood_urea 19
serum_creatinine 17
blood_pressure 12
age 9
bacteria 4
pus_cell_clumps 4
hypertension 2
diabetes_mellitus 2
coronary_artery_disease 2
appetite 1
peda_edema 1
aanemia 1
class 0
dtype: int64
```

```
In [49]: df[num_cols].isnull().sum()
```

```
Out[49]: age 9
 blood_pressure 12
 specific_gravity 47
 albumin 46
 sugar 49
 blood_glucose_random 44
 blood_urea 19
 serum_creatinine 17
 sodium 87
 potassium 88
 haemoglobin 52
 packed_cell_volume 71
 white_blood_cell_count 106
 red_blood_cell_count 131
 dtype: int64
```

```
In [50]: df[cat_cols].isnull().sum()
```

```
Out[50]: red_blood_cells 152
 pus_cell 65
 pus_cell_clumps 4
 bacteria 4
 hypertension 2
 diabetes_mellitus 2
 coronary_artery_disease 2
 appetite 1
 peda_edema 1
 aanemia 1
 class 0
 dtype: int64
```

```
In [50]: df[cat_cols].isnull().sum()
```

```
Out[50]: red_blood_cells 152
 pus_cell 65
 pus_cell_clumps 4
 bacteria 4
 hypertension 2
 diabetes_mellitus 2
 coronary_artery_disease 2
 appetite 1
 peda_edema 1
 aanemia 1
 class 0
 dtype: int64
```

```
In [51]: # filling null values, we will use two methods, random sampling for higher null values and
mean/mode sampling for lower null values
```

```
def random_value_imputation(feature):
 random_sample = df[feature].dropna().sample(df[feature].isna().sum())
 random_sample.index = df[df[feature].isnull()].index
 df.loc[df[feature].isnull(), feature] = random_sample

def impute_mode(feature):
 mode = df[feature].mode()[0]
 df[feature] = df[feature].fillna(mode)
```

```
In [52]: # filling num_cols null values using random sampling method
```

```
for col in num_cols:
 random_value_imputation(col)
```

```
In [53]: df[num_cols].isnull().sum()

Out[53]: age 0
blood_pressure 0
specific_gravity 0
albumin 0
sugar 0
blood_glucose_random 0
blood_urea 0
serum_creatinine 0
sodium 0
potassium 0
haemoglobin 0
packed_cell_volume 0
white_blood_cell_count 0
red_blood_cell_count 0
dtype: int64

In [54]: # filling "red_blood_cells" and "pus_cell" using random sampling method and rest of cat_cols using mode imputation
random_value_imputation('red_blood_cells')
random_value_imputation('pus_cell')

for col in cat_cols:
 impute_mode(col)

In [55]: df[cat_cols].isnull().sum()

Out[55]: red_blood_cells 0
pus_cell 0
pus_cell_clumps 0
bacteria 0
hypertension 0
diabetes_mellitus 0
coronary_artery_disease 0
appetite 0
peda_edema 0
aanemia 0
class 0
dtype: int64
```

## Feature Encoding

```
In [56]: for col in cat_cols:
 print(f'{col} has {df[col].nunique()} categories\n')

red_blood_cells has 2 categories
pus_cell has 2 categories
pus_cell_clumps has 2 categories
bacteria has 2 categories
hypertension has 2 categories
diabetes_mellitus has 2 categories
coronary_artery_disease has 2 categories
appetite has 2 categories
peda_edema has 2 categories
aanemia has 2 categories
class has 2 categories
```

## Label encoding

```
In [57]: from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()

for col in cat_cols:
 df[col] = le.fit_transform(df[col])
```

```
In [58]: df.head()
```

|   | age  | blood_pressure | specific_gravity | albumin | sugar | red_blood_cells | pus_cell | pus_cell_clumps | bacteria | blood_glucose_random | blood_urea | serum_creatinine | sodium | potass |
|---|------|----------------|------------------|---------|-------|-----------------|----------|-----------------|----------|----------------------|------------|------------------|--------|--------|
| 0 | 48.0 | 80.0           | 1.020            | 1.0     | 0.0   | 1               | 1        | 0               | 0        | 121.0                | 36.0       | 1.2              | 140.0  |        |
| 1 | 7.0  | 50.0           | 1.020            | 4.0     | 0.0   | 1               | 1        | 0               | 0        | 303.0                | 18.0       | 0.8              | 126.0  |        |
| 2 | 62.0 | 80.0           | 1.010            | 2.0     | 3.0   | 1               | 1        | 0               | 0        | 423.0                | 53.0       | 1.8              | 144.0  |        |
| 3 | 48.0 | 70.0           | 1.005            | 4.0     | 0.0   | 1               | 0        | 1               | 0        | 117.0                | 56.0       | 3.8              | 111.0  |        |
| 4 | 51.0 | 80.0           | 1.010            | 2.0     | 0.0   | 1               | 1        | 0               | 0        | 106.0                | 26.0       | 1.4              | 137.0  |        |

## Model Building

```
In [59]: ind_col = [col for col in df.columns if col != 'class']
dep_col = 'class'

X = df[ind_col]
y = df[dep_col]
```

```
In [60]: # splitting data into training and test set

from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.30, random_state = 0)
```

## Random Forest Classifier

```
In [61]: from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score, confusion_matrix, classification_report

rd_clf = RandomForestClassifier(criterion = 'entropy', max_depth = 11, max_features = 'auto', min_samples_leaf = 2, min_samples_split = 3, n_estimators = 100)
rd_clf.fit(X_train, y_train)

accuracy score, confusion matrix and classification report of random forest

rd_clf_acc = accuracy_score(y_test, rd_clf.predict(X_test))

print(f"Training Accuracy of Random Forest Classifier is {accuracy_score(y_train, rd_clf.predict(X_train))}")
print(f"Test Accuracy of Random Forest Classifier is {rd_clf_acc} \n")

print(f"Confusion Matrix :- \n{confusion_matrix(y_test, rd_clf.predict(X_test))}\n")
print(f"Classification Report :- \n {classification_report(y_test, rd_clf.predict(X_test))}\n")

Training Accuracy of Random Forest Classifier is 1.0
Test Accuracy of Random Forest Classifier is 0.975

Confusion Matrix :-
[[72 0]
 [3 45]]

Classification Report :-
 precision recall f1-score support

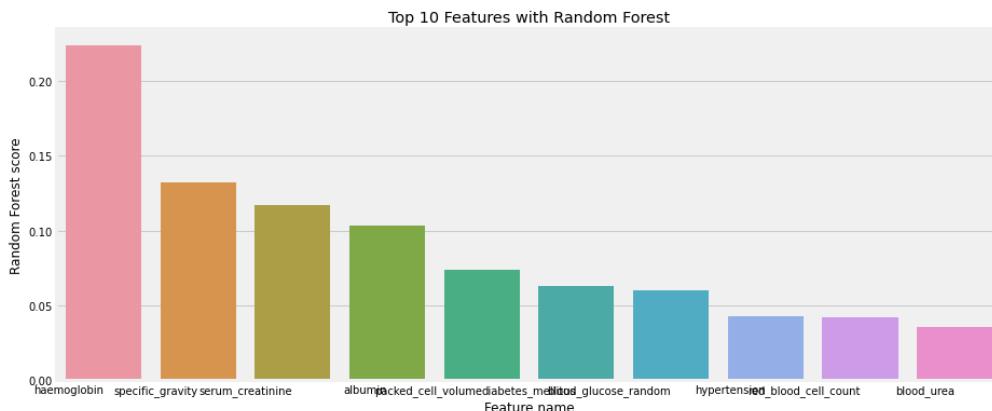
 0 0.96 1.00 0.98 72
 1 1.00 0.94 0.97 48

 accuracy 0.97 120
 macro avg 0.98 0.97 0.97 120
weighted avg 0.98 0.97 0.97 120
```

```
In [62]: # Top 10 Features
```

```
feature_scores=pd.DataFrame(rd_clf.feature_importances_,columns=['Score'],index=X_train.columns).sort_values(by='Score',ascending=False)
top10_feature = feature_scores.nlargest(n=10, columns=['Score'])

plt.figure(figsize=(14,6))
g = sns.barplot(x=top10_feature.index, y=top10_feature['Score'])
p = plt.title('Top 10 Features with Random Forest')
p = plt.xlabel('Feature name')
p = plt.ylabel('Random Forest score')
p = g.set_xticklabels(g.get_xticklabels(), horizontalalignment='right')
```



```
In [63]: top10_feature.index
```

```
Out[63]: Index(['haemoglobin', 'specific_gravity', 'serum_creatinine', 'albumin',
 'packed_cell_volume', 'diabetes_mellitus', 'blood_glucose_random',
 'hypertension', 'red_blood_cell_count', 'blood_urea'],
```

```
In [64]: X.columns
```

```
Out[64]: Index(['age', 'blood_pressure', 'specific_gravity', 'albumin', 'sugar',
 'red_blood_cells', 'pus_cell', 'pus_cell_clumps', 'bacteria',
 'blood_glucose_random', 'blood_urea', 'serum_creatinine', 'sodium',
 'potassium', 'haemoglobin', 'packed_cell_volume',
 'white_blood_cell_count', 'red_blood_cell_count', 'hypertension',
 'diabetes_mellitus', 'coronary_artery_disease', 'appetite',
 'peda_edema', 'aanemia'],
 dtype='object')
```

```
In [65]: for ele in X.columns:
 if ele not in top10_feature.index:
 X = X.drop(ele, axis = 1)
```

```
In [66]: X.head()
```

```
Out[66]: specific_gravity albumin blood_glucose_random blood_urea serum_creatinine haemoglobin packed_cell_volume red_blood_cell_count hypertension diabetes_mellitus
0 1.020 1.0 121.0 36.0 1.2 15.4 44.0 5.2 1 1
1 1.020 4.0 303.0 18.0 0.8 11.3 38.0 5.9 0 0
2 1.010 2.0 423.0 53.0 1.8 9.6 31.0 3.5 0 1
3 1.005 4.0 117.0 56.0 3.8 11.2 32.0 3.9 1 0
4 1.010 2.0 106.0 26.0 1.4 11.6 35.0 4.6 0 0
```

```
In [67]: X_train=X_train[['specific_gravity', 'haemoglobin', 'serum_creatinine', 'albumin',
 'packed_cell_volume', 'diabetes_mellitus', 'hypertension',
 'blood_glucose_random', 'red_blood_cell_count', 'blood_urea']]
X_test=X_test[['specific_gravity', 'haemoglobin', 'serum_creatinine', 'albumin',
 'packed_cell_volume', 'diabetes_mellitus', 'hypertension',
 'blood_glucose_random', 'red_blood_cell_count', 'blood_urea']]
rd_clf.fit(X_train,y_train)
```

```
Out[67]: RandomForestClassifier(criterion='entropy', max_depth=11, min_samples_leaf=2,
 min_samples_split=3, n_estimators=130)
```

```
In [68]: # Prediction 1
prediction = rd_clf.predict([[1.025,15.8,1.1,0.0,53.0,0,0,131.0,6.1,18.0]])[0]
if prediction:
 print('Oops! You have Chronic Kidney Disease.')
else:
 print("Great! You don't have Chronic Kidney Disease.")

Oops! You have Chronic Kidney Disease.
```

```
In [69]: # Prediction 2
prediction = rd_clf.predict([[1.020,15.4,1.2,1.0,44.0,1,1,121.0,5.2,36.0]])[0]
if prediction:
 print('Oops! You have Chronic Kidney Disease.')
else:
 print("Great! You don't have Chronic Kidney Disease.")

Great! You don't have Chronic Kidney Disease.
```

```
In [70]: pip install ibm_watson_machine_learning

Requirement already satisfied: ibm_watson_machine_learning in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (1.0.257)
Requirement already satisfied: certifi in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm_watson_machine_learning) (2022.9.24)
Requirement already satisfied: tabulate in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm_watson_machine_learning) (0.8.9)
Requirement already satisfied: importlib-metadata in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm_watson_machine_learning) (4.8.2)
Requirement already satisfied: packaging in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm_watson_machine_learning) (21.3)
Requirement already satisfied: urllib3 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm_watson_machine_learning) (1.26.7)
Requirement already satisfied: pandas<1.5.0,>=0.24.2 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm_watson_machine_learning) (1.3.4)
Requirement already satisfied: lmomond in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm_watson_machine_learning) (0.3.3)
Requirement already satisfied: ibm-cos-sdk==2.11.* in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm_watson_machine_learning) (2.11.0)
Requirement already satisfied: requests in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm_watson_machine_learning) (2.26.0)
Requirement already satisfied: ibm-cos-sdk-core==2.11.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm-cos-sdk==2.11.*->ibm_watson_machine_learning) (2.11.0)
Requirement already satisfied: ibm-cos-sdk-s3transfer==2.11.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm-cos-sdk==2.11.*->ibm_watson_machine_learning) (2.11.0)
Requirement already satisfied: jmespath<1.0.0,>=0.7.1 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm-cos-sdk==2.11.*->ibm_watson_machine_learning) (0.10.0)
Requirement already satisfied: python-dateutil<3.0.0,>=2.1 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from ibm-cos-sdk-core==2.11.0->ibm-cos-sdk==2.11.*->ibm_watson_machine_learning) (2.8.2)
Requirement already satisfied: pytz>=2017.3 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from pandas<1.5.0,>=0.24.2->ibm_watson_machine_learning) (2021.3)
Requirement already satisfied: numpy>=1.17.3 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from pandas<1.5.0,>=0.24.2->ibm_watson_machine_learning) (1.20.3)
Requirement already satisfied: six>=1.5 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from python-dateutil<3.0.0,>=2.1->ibm-cos-sdk-core==2.11.0->ibm-cos-sdk==2.11.*->ibm_watson_machine_learning) (1.15.0)
Requirement already satisfied: charset-normalizer~2.0.0 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from requests->ibm_watson_machine_learning) (2.0.4)
Requirement already satisfied: idna<4,>=2.5 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from requests->ibm_watson_machine_learning) (3.3)
Requirement already satisfied: zipp>=0.5 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from importlib-metadata->ibm_watson_machine_learning) (3.6.0)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in /opt/conda/envs/Python-3.9/lib/python3.9/site-packages (from packaging->ibm_watson_machine_learning) (3.0.4)
```

```
In [71]: from ibm_watson_machine_learning import APIClient
wml_credentials = {
 "url": "https://us-south.ml.cloud.ibm.com",
 "apikey": "0LQTKaIU-zf6eoYKE_5xaUY1A8dU5owCbBs1h4G1NQ"
}
client = APIClient(wml_credentials)

In [72]: wml_client = APIClient(wml_credentials)
wml_client.spaces.list()

Note: 'limit' is not provided. Only first 50 records will be displayed if the number of records exceed 50

ID NAME CREATED
166c647b-d1f8-4fb5-925d-dc7d47bd153b kidneydeploy 2022-11-11T14:17:07.335Z

In [73]: space_id = "166c647b-d1f8-4fb5-925d-dc7d47bd153b"

In [74]: wml_client.set.default_space(space_id)

Out[74]: 'SUCCESS'
```

```
In [75]: wml_client.software_specifications.list(500)
```

```

NAME ASSET_ID
default_py3_6 0062b8c9-8b7d-44a0-a9b9-46c416adcb9 base
kernel-spark3.2-scala2.12 020d69ce-7ac1-5e68-ac1a-31189867356a base
pytorch-onnx_1.3-py3.7-edt 069ea134-3346-5748-b513-49120e15d288 base
scikit-learn_0.20-py3.6 00c5a1d0-9c1e-4473-a344-eb7b6f65ff687 base
spark-mllib_3.0-scala_2.12 00fc4ff0-90a7-5899-b9ed-1ef348aebdee base
pytorch-onnx_rt22.1-py3.9 0b848dd4-e681-5599-be41-b5f6fccc6471 base
ai-function_0.1-py3.6 0cd8bf1e-5376-4f4d-92d2-dab3b69a9bda base
shiny_r3.6 0d6e79df-875e-4f24-8ae9-62dcc2148306 base
tensorflow_2.4-py3.7-horovod 109259ba-307d-563d-9b62-4eb7d6ab3f22 base
pytorch-klt_rt22.2-py3.10 10a1c12d6-6b30-4cc4-8392-3e922c096a92 base
tensorflow_1.15-py3.6-dd1 111e41b3-de2d-5422-a4de-bf776828c4b7 base
autoai-klt_rt22.2-py3.10 125b6dca-5b1f-5e8d-972a-b251688ccf40 base
runtime_22.1-py3.9 12b83a17-24db-5082-900f-0ab31fbfd3cb base
scikit-learn_0.22-py3.6 154010fa-5b3b-4a1c-82af-4d5ee5abb85 base
default_r3.6 1670aec3-ab34-4b87-8aa0-a4a3c8296a36 base
pytorch-onnx_1.3-py3.6 1b6029a-cc97-56d4-b8e0-39c3880dbbe7 base
kernel-spark3.3-r3.6 1c9e5454-f216-59dd-a20e-474a5cdf5988 base
pytorch-onnx_rt22.1-py3.9-edt 1d3d2168-7ed5-5b59-9b6c-9d0800bd37f base
tensorflow_2.1-py3.6 1e625b84-deed-5d0e-b6a5-37bdf1665666 base
spark-mllib_3.2 20047f72-0a98-58c7-9ff5-a77b012eb8f5 base
tensorflow_2.4-py3.8-horovod 217c16f6-1787-56b7-824a-b19f20564c49 base
runtime_22.1-py3.9-cuda 26215f05-08c3-5a41-a1b0-dab3d6306ce658 base
do_py3.8 295addb5-9ef9-547e-9bf4-92ae3563e720 base
autoai-ts_3.8-py3.8 2aa0c932-798f-5ae9-abd6-15e6c2402fb5 base
tensorflow_1.15-py3.6 2b73a275-7cbf-420b-a912-eae7f4346e0bc base
kernel-spark3.3-py3.9 2b7961e2-e3b1-5a8c-a491-482c8368839a base
pytorch_1.2-py3.9 2c8ef57d-2687-4b7d-acce-01f94976dacf1 base
spark-mllib_2.3 2e51f700-bca0-4b0d-88dc-5c6791338875 base
pytorch-onnx_1.1-py3.6-edt 32983cea-3f32-4400-8965-dde874a8d67e base
spark-mllib_3.0-py37 36507ebe-8770-55ba-ab2a-eafe787600e9 base
spark-mllib_2.4 390d21f8-e58b-4fac-9c55-d7ceda621326 base
autoai-ts_rt22.2-py3.10 396b2e83-0953-5b86-9a55-7ce1628a406f base
xgboost_0.82-py3.6 39e31acd-5f30-41dc-a4e4-60233a80306e base
pytorch-onnx_1.2-py3.6-edt 40589d0e-7019-4e28-8daa-fb03b6f4fe12 base
pytorch-onnx_rt22.2-py3.10 40e73f55-783a-5535-b3fa-0c8b94291431 base
default_r36py38 41c247d3-45f8-5a71-b065-8580229facf0 base
autoai-ts_rt22.1-py3.9 4269d2ee-07ba-5d40-8f66-2d495bcb71f7 base
autoai-obm_3.0 42b92e18-d9ab-56f7-988a-4249ba1ed5f7 base
pmml_3.0_4.3 439cbc95-16f1-5bc5-bee8-81b8af80e9c7 base
spark-mllib_2.4-r_3.6 49403dff-92e9-4c87-a3d7-a42d0021c095 base
xgboost_0.90-py3.6 4ff866c2-1343-4c18-8a1-689c965304d3 base
pytorch-onnx_1.1-py3.6 50f95b2a-bc16-43bb-b94-b0bed208c60b base
autoai-ts_3.9-py3.8 52c57136-80fa-572e-8728-a5e7ccb42cde base
spark-mllib_2.4-scala_2.11 55a70f99-7320-4b5e-9fb9-9ed55a43af5 base
spark-mllib_3.0 5c1b6ca2-4977-5c2e-9439-ffd44ea8fe9 base
autoai-obm_2.0 5c2e37fa-80bb-5e77-840f-d912469614ee base
spss-modeler_18.1 5c3cad7e-507f-4b2a-a9a3-ab53a21deeb8 base
cuda-py3.8 5d3232bf-c86b-5df4-a2cd-7bb8701cd4e base
autoai-kb_3.0-py3.7 632d4b22-10aa-5180-88f0-f52dfb6444ad7 base
pytorch-onnx_1.7-py3.8 6343dc0c-b562-5bf9-a2d4-ea90a478456b base
spark-mllib_2.3-r_3.6 6586b9e3-ccd6-4f92-900f-0f8cb2bdfe0c base

```

```
spark-mllib_2.4-py37 7abc092b-0685-552b-a122-a339ea3cdbab base
caffe_1.0-py3.6 7bb3dbe2-d46e-4145-918d-b6d84a9a3b6b base
pytorch-onnx_1.7-py3.7 812c6631-42b7-5613-982b-02098e6c909c base
cuda-py3_6 8279e0ce-4d12-40e6-8787-a7b9e0f62770 base
tensorflow_1.15-py3.6-horovod 8964680e-d5e4-5bb8-919b-8342cc0d9df8 base
hybrid_0.1 8c1a58c6-62b5-4dc4-987a-df751c2756b6 base
pytorch-onnx_1.3-py3.7 8d5d8a87-a912-54cf-81ec-3914adaa988d base
caffe-imb_1.0-py3.6 8d863266-7927-4d1e-97d7-56a7f4ca019b base
spss-modeler_17.1 902d0051-848d-4a56-ab6b-8f6aa6fdeabb base
do_12.10 9100fd72-8159-4eb9-8a0b-a87e12eefaf36 base
do_py3.7 9447fa8b-2051-4d24-9eef-5acb0e3c59f8 base
spark-mllib_3.0-r_3.6 94bb6052-c837-589d-83f1-f4142f219e32 base
cuda-py3.7-opence 94e9652b-7fd2-59d5-ba5a-23a414e488f base
nlp-py3.8 96e60351-99d4-5a1c-9cc0-473a1cb5a864 base
cuda-py3.7 9a44990c-1aa1-4c7d-baf8-c40990b11741c base
hybrid_0.2 9b3f9040-9cee-44d8-8d7a-780600f542f7 base
spark-mllib_3.0-py38 9f7a8f1c-4d3c-5e65-ab90-41fa8d2d418 base
autoai-kb_3.3-py3.7 a545ccaa-02df-5c61-9e88-99b809dc79af base
spark-mllib_3.0-py39 a6082a27-5acc-5163-b2c-6b96916eb5e0 base
runtime_22.1-py3.9-do a7e7fdb1-1d03-5544-994d-e5ec845ce99a base
default_py3.8 ab9e1b80-f2ce-592c-a7d2-4f2344ff77194 base
tensorflow_rt22.1-py3.9 acd9c798-6974-5d2f-a657-ce06986df4d base
kernel-spark3.2-py3.9 ad7033ee-794e-58cf-812e-a95f4b64b207 base
autoai-obm_2.0_with Spark 3.0 af10f35f-69fa-5d66-9b95-acb58434263a base
default_py3.7_opence c2057d4d-f42c-5f77-a02f-72bbdb3282c9 base
tensorflow_2.1-py3.7 c4032338-2a40-500a-beef-b01ba2667e27 base
do_py3.7_opence cc8f8976-b74a-551a-bb66-6377ff8d65b4 base
spark-mllib_3.3 d11f2434-4fc7-5b87-8a62-755da4efdfaf8 base
autoai-kb_3.0-py3.6 d139f196-e04b-5d8b-914b-9a10cal1fa91a base
spark-mllib_3.0-py36 d82546d5-dd78-5ffb-9131-2e309bc56ed base
autoai-kb_3.4-py3.8 da9b39c3-758c-5a4f-9cf4-d57d4d4bc395 base
kernel-spark3.2-r3.6 db2f4e4d-6d41-5d05-9972-73c654a60e0a base
autoai-kb_rt22.1-py3.9 db6afe93-665f-5910-b117-d879897404d9 base
tensorflow_rt22.1-py3.9-horovod dda170cc-a67-5d47-9b7a-cf84c6987fae base
autoai-ts_1.0-py3.7 defea04f0-0c42-5147-9711-89f9904299db base
tensorflow_2.1-py3.7-horovod e384fce5-fdd1-53f8-bc71-11326c9c635f base
default_py3.7 e4429883-c883-42b6-87a8-f419d4088cd base
do_22.1 e51999ba-6452-5f1f-8287-1722888b6652 base
autoai-obm_3.2 eae86aab-da30-5229-a6a6-1d0d4e368983 base
tensorflow_rt22.2-py3.10 f65b2d165-f057-55de-b5cb-f97fc2c0f393 base
do_20.1 f686ccdf9-7904-5f9d-a732-01bb0d6b10dc5 base
pytorch-onnx_rt22.2-py3.10-edt f8a05d07-e7cd-57bb-a10b-23f1d4b837a base
scikit-learn_0.19-py3.6 f963fa9d-4bb7-5652-9c5d-8d9289ef6ad9 base
tensorflow_2.4-py3.8 fe185c44-9a99-5425-986b-59bd1d2eda46 base

```

```
In [76]: MODEL_NAME = 'kidneyfinalModel'
DEPLOYMENT_NAME = 'demo_deploy'
DEMO_MODEL = rd_clf
```

```
In [77]: software_spec_uid = wml_client.software_specifications.get_id_by_name('runtime-22.1-py3.9')
```

```
In [78]: model_props={
 wml_client.repository.ModelMetaNames.NAME: MODEL_NAME,
 wml_client.repository.ModelMetaNames.TYPE: "scikit-learn_1.0",
 wml_client.repository.ModelMetaNames.SOFTWARE_SPEC_UID: software_spec_uid
}
```

```
In [79]: model_details = wml_client.repository.store_model(
 model=DEMO_MODEL,
 meta_props=model_props,
 training_data=X_train,
 training_target=y_train)
```

```
In [80]: model_details
```

```
Out[80]: {'entity': {'hybrid_pipeline_software_specs': [],
 'label_column': 'class',
 'schemas': {'input': [{'fields': [{'name': 'specific_gravity',
 'type': 'float64'},
 {'name': 'haemoglobin', 'type': 'float64'},
 {'name': 'serum_creatinine', 'type': 'float64'},
 {'name': 'albumin', 'type': 'float64'},
 {'name': 'packed_cell_volume', 'type': 'float64'},
 {'name': 'diabetes_mellitus', 'type': 'int64'},
 {'name': 'hypertension', 'type': 'int64'},
 {'name': 'blood_glucose_random', 'type': 'float64'},
 {'name': 'red_blood_cell_count', 'type': 'float64'},
 {'name': 'blood_urea', 'type': 'float64'}],
 'id': '1',
 'type': 'struct'}],
 'output': []},
 'software_spec': {'id': '12b83a17-24d8-5082-900f-0ab31fbfd3cb',
 'name': 'runtime-22.1-py3.9'},
 'type': 'scikit-learn_1.0'},
 'metadata': {'created_at': '2022-11-11T14:18:25.979Z',
 'id': 'f72876c3-2e47-4ba3-b4a5-423fb3e06e1e',
 'modified_at': '2022-11-11T14:18:29.196Z',
 'name': 'kidneyfinalModel',
 'owner': 'IBMid-661004221F',
 'resource_key': '3d66e9c9-7527-4e4d-ada5-9fa505d9d48f',
 'space_id': '166c647b-d1f8-4fb5-925d-dc7d47bd153b'},
 'system': {'warnings': []}}}
```

## scoring\_app.py:

```

1 from flask import Flask, render_template , request
2
3 import requests
4
5 # NOTE: you must manually set API_KEY below using information retrieved from your IBM Cloud account.
6 API_KEY = "0LQTKaiU-zf6geoYKE_5xaUV1ABdU5owCDBs1h4G1NjQ"
7 token_response = requests.post('https://iam.cloud.ibm.com/identity/token', data={"apikey":API_KEY, "grant_type": 'urn:ibm:params:oauth:grant-type:apikey'})
8 mltoken = token_response.json()["access_token"]
9
10 header = {'Content-Type': 'application/json', 'Authorization': 'Bearer ' + mltoken}
11
12
13
14 app = Flask(__name__)
15
16 @app.route('/')
17 def home():
18 return render_template("home.html")
19
20 @app.route('/index', methods=['POST','GET'])
21 def index():
22 return render_template("index.html")
23
24 @app.route('/result', methods=['POST','GET'])
25 def result():
26 return render_template("result.html")
27
28 @app.route('/about', methods=['POST','GET'])
29 def about():
30 return render_template("about.html")
31
32
33 @app.route('/login', methods=['POST','GET'])
34 def login():
35 p =request.form["sg"]
36 q =request.form["hemo"]
37 r =request.form["sc"]
38 s =request.form["al"]
39 t =request.form["pcv"]
40 u =request.form["u"]
41 if (u=="yes"):
42 u1=1
43 elif (u=="no"):
44 u1=0
45 v =request.form["v"]
46 if (v=="yes"):
47 v1=1
48 elif (v=="no"):
49 v1=0
50 x=request.form["bgr"]
51 y=request.form["rbc"]
52 z=request.form["bu"]
53
54
55 A=[[float(p),float(q),float(r),float(s),float(t),float(u1),float(v1),float(x),float(y),float(z)]]
56 payload_scoring = {"input_data": [{"fields": [[{"f0","f1","f2","f3","f4","f5","f6","f7","f8","f9"]], "values":A }]}
57
58
59 response_scoring = requests.post('https://us-south.ml.cloud.ibm.com/ml/v4/deployments/f96f18ff-539c-4339-9575-739a6a1c310b/predictions?version=2022-11-11', json=payload_scoring,
60 headers={'Authorization': 'Bearer ' + mltoken})
61 print("Scoring response")
62 print(response_scoring.json())
63
64 predictions = response_scoring.json()
65 pred=predictions['predictions'][0]['values'][0][0]
66 print(pred)
67
68 return render_template("result.html", y = pred)
69
70
71 if __name__ == '__main__':
72 app.run(debug = True)
73

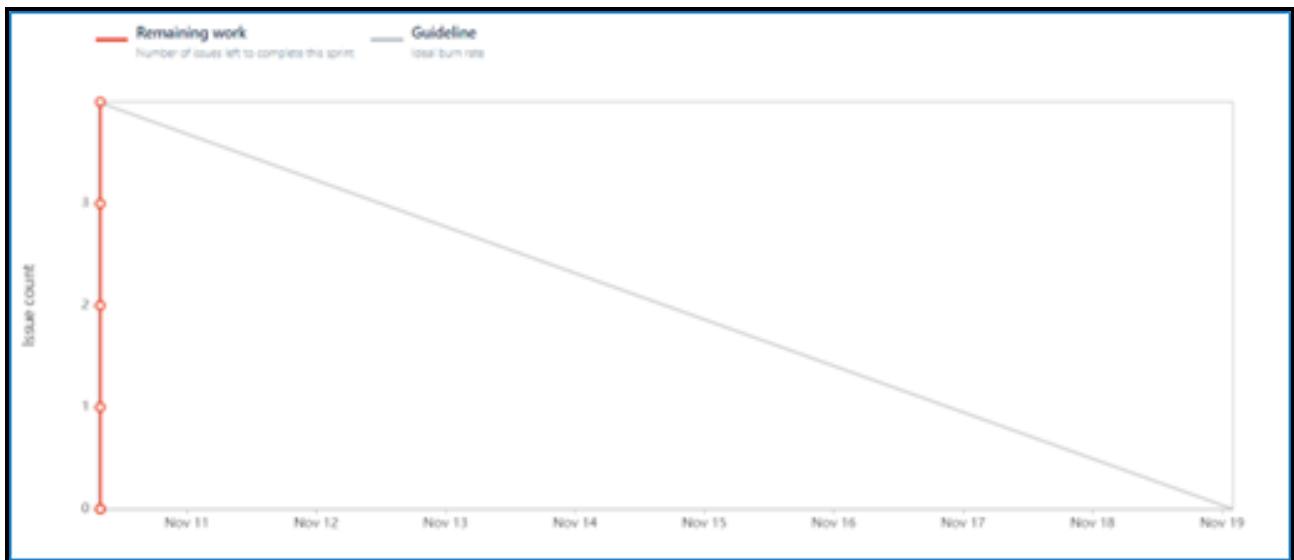
```

## 8. TESTING

### 8.1 Test Cases:

| Test case ID         | Feature Type | Component                      | Test Scenario                                   | Pre-Requisite | Steps To Execute                                                                                    | Test Data                                                                                                                                                                                                                             | Expected Result                                                                                                                                                                                               | Actual Result                               | Status | Comments             |
|----------------------|--------------|--------------------------------|-------------------------------------------------|---------------|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|--------|----------------------|
| InitialScreen_TC_001 | Functional   | Home Page                      | Verify user able to see the Prediction page     |               | 1.Enter URL<br>2.Click on Prediction button<br>3.Verify going to next page                          | <a href="https://localhost:5000">https://localhost:5000</a>                                                                                                                                                                           | Entering into data input page                                                                                                                                                                                 | Working as expected                         | Pass   | Normal test case     |
| Input_data_TC_002    | Functional   | Prediction value input page UI | Verify user able to enter input value           |               | 1.Check entering into prediction page<br>2.Check if user can enter value                            | <a href="https://localhost:5000">https://localhost:5000</a>                                                                                                                                                                           | Application should show below UI elements to enter <b>numeric values</b> :<br>a.Blood Urea<br>b.Blood Glucose Random Software should accept only numeric values                                               | Should allow entering numeric values        | Pass   | Normal test case     |
| Input_data_TC_003    | Functional   | Prediction value input page UI | Verify user able to enter input value           |               | 1.Check entering into prediction page<br>2.Check if user can select option from drop down box       | <a href="https://localhost:5000">https://localhost:5000</a>                                                                                                                                                                           | Application should show below UI elements to select from drop down menu:<br>a.Select Anemia<br>b.Select Coronary Artery Disease<br>c.Select Pus Cell<br>d.Select Red Blood Cell<br>e.Select Diabetes Mellitus | should allow selection from pull down menu  | Pass   | Normal test case     |
| Input_data_TC_004    | Functional   | Prediction value input page UI | Verify user able to enter input value           |               | 1.Check entering into prediction page<br>2.Check if user can select option from drop down box       | <a href="https://localhost:5000">https://localhost:5000</a>                                                                                                                                                                           | Application should show below UI elements to enter <b>alphabetic characters</b> :<br>a.Blood Urea<br>b.Blood Glucose Random Software should accept only numeric values                                        | Should not allow entering alphabetic values | Pass   | Robustness test case |
| Result_data_TC_005   | Functional   | Prediction Result Page         | Verify Chronic Kidney Disease (CKD) test values |               | 1.Enter submit button after entering values<br>2.Redirect to result page and display correct result | a.Specific gravity : 1.02<br>b.Haemoglobin: 15.4<br>c.Serum Creatine: 1.2<br>d.Albumin: 1<br>e.Packed cell volume: 44<br>f.Diabetes mellitus: 1<br>g.Hypertension: 1<br>h.Glucose random: 121<br>i.RBC count: 5.2<br>j.Blood urea: 36 | Application should show Chronic Kidney Disease                                                                                                                                                                | Showed CKD                                  | Pass   | Normal test case     |

|                    |            |                        |                                                       |  |                                                                                                     |                                                                                                                                                                                                                                        |                                                   |               |      |                  |
|--------------------|------------|------------------------|-------------------------------------------------------|--|-----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|---------------|------|------------------|
| Result_data_TC_006 | Functional | Prediction Result Page | Verify No Chronic Kidney Disease (No CKD) test values |  | 1.Enter submit button after entering values<br>2.Redirect to result page and display correct result | a.Specific gravity : 1.025<br>b.Haemoglobin: 15.8<br>c.Serum Creatine: 1.1<br>d.Albumin: 0<br>e.Packed cell volume: 53<br>f.Diabetes mellitus: 0<br>g.Hypertension: 0<br>h.Glucose random: 131<br>i.RBC count: 6.1<br>j.Blood urea: 18 | Application should show No Chronic Kidney Disease | Showed No CKD | Pass | Normal test case |
| Result_data_TC_007 | Functional | Prediction Result Page | Verify Chronic Kidney Disease (CKD) test values       |  | 1.Enter submit button after entering values<br>2.Redirect to result page and display correct result | a.Specific gravity : 1.02<br>b.Haemoglobin: 11.5<br>c.Serum Creatine: 0.8<br>d.Albumin: 4<br>e.Packed cell volume: 38<br>f.Diabetes mellitus: 0<br>g.Hypertension: 0<br>h.Glucose random: 112<br>i.RBC count: 6.3<br>j.Blood urea: 18  | Application should show Chronic Kidney Disease    | Showed CKD    | Pass | Normal test case |

**SPRINT 3 BURNDOWN CHART:****SPRINT 4 BURNDOWN CHART:**

## 8.2 User Acceptance Testing: Purpose of Document

The purpose of this document is to briefly explain the test coverage and open issues of the Early Detection of Chronic Kidney Disease project at the time of the release to User Acceptance Testing (UAT).

## Defect Analysis

This report shows the number of resolved or closed bugs at each severity level, and how they were resolved

| Resolution     | Severity 1 | Severity 2 | Severity 3 | Severity 4 | Subtotal |
|----------------|------------|------------|------------|------------|----------|
| By Design      | 3          | 1          | 1          | 1          | 6        |
| Duplicate      | 4          | 0          | 2          | 0          | 6        |
| External       | 2          | 2          | 0          | 1          | 5        |
| Fixed          | 1          | 1          | 1          | 1          | 4        |
| Not Reproduced | 0          | 0          | 0          | 0          | 0        |
| Skipped        | 0          | 0          | 0          | 0          | 0        |
| Won't Fix      | 0          | 4          | 0          | 0          | 0        |
| Totals         | 10         | 4          | 4          | 3          | 21       |

## Test Case Analysis

This report shows the number of test cases that have passed, failed, and untested

| Section                           | Total Cases | Not Tested | Fail | Pass |
|-----------------------------------|-------------|------------|------|------|
| Home Page                         | 1           | 0          | 0    | 1    |
| User Input                        | 5           | 0          | 1    | 4    |
| Chronic Kidney Disease testing    | 2           | 0          | 0    | 2    |
| No Chronic Kidney Disease testing | 5           | 0          | 1    | 4    |
| Chat Bot                          | 2           | 0          | 0    | 2    |
| About Page                        | 1           | 0          | 0    | 1    |

## 9. RESULTS

### 9.1 Performance Metrics:

#### Model Performance Testing:

Project team shall fill the following information in model performance testing template.

| S.No. | Parameter      | Values                                                                                                                                                                | Screenshot |
|-------|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| 1.    | Metrics        | <b>Regression Model:</b><br>MAE - , MSE - , RMSE - , R2 score -<br><br><b>Classification Model:</b><br>Confusion Matrix - , Accuracy Score- & Classification Report - | See below  |
| 2.    | Tune the Model | Hyperparameter Tuning -<br>Validation Method -                                                                                                                        | See below  |

#### 1. Metrics

##### Random Forest Model:

##### Random Forest Classifier

```
from sklearn.ensemble import RandomForestClassifier

rd_clf = RandomForestClassifier(criterion = 'entropy', max_depth = 11, max_features = 'auto', min_samples_leaf = 2, min_samples_s
rd_clf.fit(X_train, y_train)

accuracy score, confusion matrix and classification report of random forest

rd_clf_acc = accuracy_score(y_test, rd_clf.predict(X_test))

print(f"Training Accuracy of Random Forest Classifier is {accuracy_score(y_train, rd_clf.predict(X_train))}\n")
print(f"Test Accuracy of Random Forest Classifier is {rd_clf_acc} \n")

print(f"Confusion Matrix :- \n{confusion_matrix(y_test, rd_clf.predict(X_test))}\n")
print(f"Classification Report :- \n {classification_report(y_test, rd_clf.predict(X_test))}\n")

```

Training Accuracy of Random Forest Classifier is 0.9964285714285714  
 Test Accuracy of Random Forest Classifier is 0.9833333333333333

Confusion Matrix :-  
 [[72 0]  
 [ 2 46]]

Classification Report :-

|              | precision | recall | f1-score | support |
|--------------|-----------|--------|----------|---------|
| 0            | 0.97      | 1.00   | 0.99     | 72      |
| 1            | 1.00      | 0.96   | 0.98     | 48      |
| accuracy     |           |        | 0.98     | 120     |
| macro avg    | 0.99      | 0.98   | 0.98     | 120     |
| weighted avg | 0.98      | 0.98   | 0.98     | 120     |

## 2.Tune the Model:

### Hyperparameter Tuning:

- The number of features is important and should be tuned in random forest classification.
- Initially all parameters in the dataset are taken as independent values to arrive at the dependent decision of Chronic Kidney Disease or No Chronic Kidney Disease.
- But the result was not accurate so used only 8 more correlated values as independent values to arrive at the dependent decision of Chronic Kidney Disease or not.

### Validation Method:

It involves partitioning the training data set into subsets, where one subset is held out to test the performance of the model. This data set is called the validation data set.

**As our model already shows a good accuracy without overfitting and underfitting, no tuning is required for random forest model.**

| NFT - Risk Assessment    |                                                                  |                           |                                |                   |                   |                         | Risk Score                                                               | Justification     |
|--------------------------|------------------------------------------------------------------|---------------------------|--------------------------------|-------------------|-------------------|-------------------------|--------------------------------------------------------------------------|-------------------|
| S.No                     | Project Name                                                     | Scope/Feature             | Functional Changes             | Hardware Changes  | Software Changes  | Impact of Downtime      | Load/Volume Changes                                                      |                   |
| 1                        | Early detection of chronic kidney disease using machine learning | New                       | No Changes                     | No Changes        | Low               |                         | No Changes                                                               | GREEN             |
| 2                        | Early detection of chronic kidney disease using machine learning | New                       | Low                            | No Changes        | Moderate          |                         | > \$ 10 K                                                                | ORANGE            |
|                          |                                                                  |                           |                                |                   |                   |                         |                                                                          |                   |
|                          |                                                                  |                           |                                |                   |                   |                         |                                                                          |                   |
| NFT - Detailed Test Plan |                                                                  |                           |                                |                   |                   |                         |                                                                          |                   |
| S.No                     | Project Overview                                                 | NFT Test approach         | Assumptions/Dependencies/Risks | Approvals/SignOff |                   |                         |                                                                          |                   |
|                          | Early detection of chronic kidney disease using machine learning | load and smoke Test cases | Dependency on IBM cloud team   | IBM team          |                   |                         |                                                                          |                   |
| End Of Test Report       |                                                                  |                           |                                |                   |                   |                         |                                                                          |                   |
| S.No                     | Project Overview                                                 | NFT Test approach         | NFR - Met                      | Test Outcome      | GO/NO-GO decision | Recommendations         | Identified Defects (Detected/Closed/Open)                                | Approvals/SignOff |
| 1                        | Early detection of chronic kidney disease using machine learning | load and smoke test cases | yes                            | success           | GO decision       | Good to proceed and use | No defects. However accuracy increased by using random forest classifier |                   |
|                          |                                                                  |                           |                                |                   |                   |                         |                                                                          |                   |
|                          |                                                                  |                           |                                |                   |                   |                         |                                                                          |                   |

## 10. ADVANTAGES & DISADVANTAGES

This software has various advantages where it can be used as an expert guide to doctors for early detection of chronic kidney disease. It is also seen in performance metrics that it has an accuracy of 95% which gives good confidence to the users.

Machine Learning is autonomous but highly susceptible to errors. Suppose you train an algorithm with data sets small enough to not be inclusive. You end up with biased predictions coming from a biased training set.

## 11. CONCLUSION

This Project has helped team members to understand various concepts of Machine learning, Flask file, IBM cloud and Python notebook.

This project can be scaled for usage in prediction of other chronic diseases which will help doctors in diagnosis of disease at an early stage thereby helping in early detection of various disease.



## 12. FUTURE SCOPE

This software can be used to detect various other chronic diseases by modifying the dataset and the user inputs received. The model can be further trained with enormous amount of data to improve the accuracy.

## 13. APPENDIX

<https://github.com/IBM-EPBL/IBM-Project-4553-1658734414>

**Project Demo Link**

<https://github.com/IBM-EPBL/IBM-Project-4553-1658734414/blob/main/Final%20Deliverables/PNT2022TMID00708-CKD.mp4>

or

[https://drive.google.com/file/d/1RktX9k2IiIcAIQi0KWrT8oGyyH\\_MrNX/view?usp=sharing](https://drive.google.com/file/d/1RktX9k2IiIcAIQi0KWrT8oGyyH_MrNX/view?usp=sharing)

**Source code:** Given as screen shots and available in github.