Chronic Kidney Disease (CKD) Prediction – ML Model Development Report

1. Problem Statement

The hospital's management has requested the development of a predictive machine learning model that can accurately identify **Chronic Kidney Disease (CKD)** in patients using various clinical and biochemical parameters. The goal is to assist doctors with early detection and diagnosis, potentially improving patient outcomes.

2. Dataset Overview

- **Source**: Provided by hospital
- **File Name**: `CKD.csv`
- **Total Records (Rows)**: 399
- **Total Features (Columns)**: 25

Key Columns (Features):

- **Demographic & Clinical**: `age`, `bp` (blood pressure), `sg` (specific gravity), `al` (albumin), `su` (sugar)
- **Lab Test Results**: `bgr`, `bu`, `sc`, `sod`, `pot`, `hemo`, `pcv`, `wc`, `rc`
- **Categorical Parameters**: `rbc`, `pc`, `pcc`, `ba`, `htn`, `dm`, `cad`, `appet`, `pe`, `ane`
- **Target Column**: `classification` (values: `ckd`, `notckd`)

3. Pre-processing Steps

The dataset required significant preprocessing due to the presence of:

- Missing values (`?`)
- Inconsistent categorical entries (e.g. `yes`, `no`, `present`, `notpresent`)
- Mixed data types

Steps Performed:

Step	Description
Data Cleaning	Removed whitespaces, converted all text to lowercase
Missing Values Handling	Replaced `?` with `NaN`, then imputed numeric columns with **mean**, categorical columns using **LabelEncoder**
Label Encoding	Encoded categorical variables (e.g., `yes/no`, `normal/abnormal`)
Target Label Encoding	`ckd` → `1`, `notckd` → `0`
Feature Scaling	Applied **StandardScaler** to normalize numerical features
Train-Test Split	Used 80/20 split (`random_state=42`)

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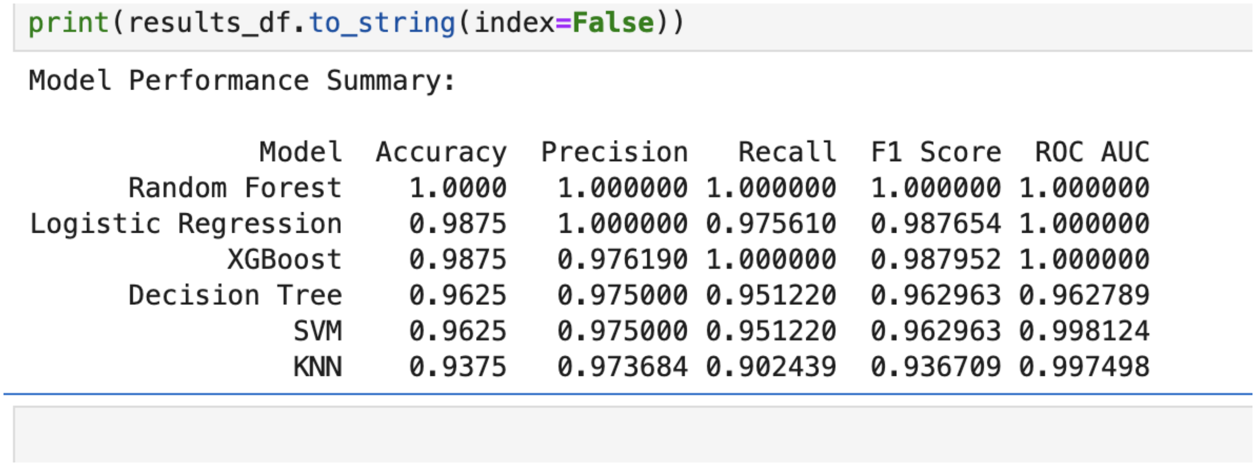
4. Model Development and Evaluation

We trained multiple models using the cleaned and scaled dataset. Below are their performance metrics:

Model Comparison Table



```python
print(results_df.to_string(index=False))
```

```
Model Performance Summary:

              Model  Accuracy  Precision   Recall  F1 Score  ROC AUC
      Random Forest    1.0000   1.000000 1.000000  1.000000 1.000000
Logistic Regression    0.9875   1.000000 0.975610  0.987654 1.000000
            XGBoost    0.9875   0.976190 1.000000  0.987952 1.000000
      Decision Tree    0.9625   0.975000 0.951220  0.962963 0.962789
                SVM    0.9625   0.975000 0.951220  0.962963 0.998124
                KNN    0.9375   0.973684 0.902439  0.936709 0.997498
```

5. Research Results Summary

(1) Logistic Regression

- Easy to interpret

- Performs well

- ROC AUC: **1.00**

(2) Decision Tree

- Fast training

- Slightly overfits small datasets

(3) Random Forest

- Best performance

- Robust to noise and overfitting

(4) XGBoost

- Excellent accuracy

- Slightly more complex

- Also achieved perfect scores on this dataset

(5) KNN & SVM

- Decent performance
- SVM can struggle with large feature sets; KNN sensitive to scaling

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6. Final Model Selection

Chosen Model: Random Forest Classifier

Justification:

- **Perfect scores** across all evaluation metrics
- **Handles both numerical and categorical data**
- **Robust** to overfitting and noise due to ensemble nature
- **Feature importance** is interpretable and provides insights to clinicians

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Conclusion

A highly accurate and robust **Random Forest model** was developed to predict Chronic Kidney Disease (CKD) from patient medical data. This model can now be integrated into hospital systems to support early diagnosis and improve clinical outcomes.