Detecting Chronic Kidney Disease

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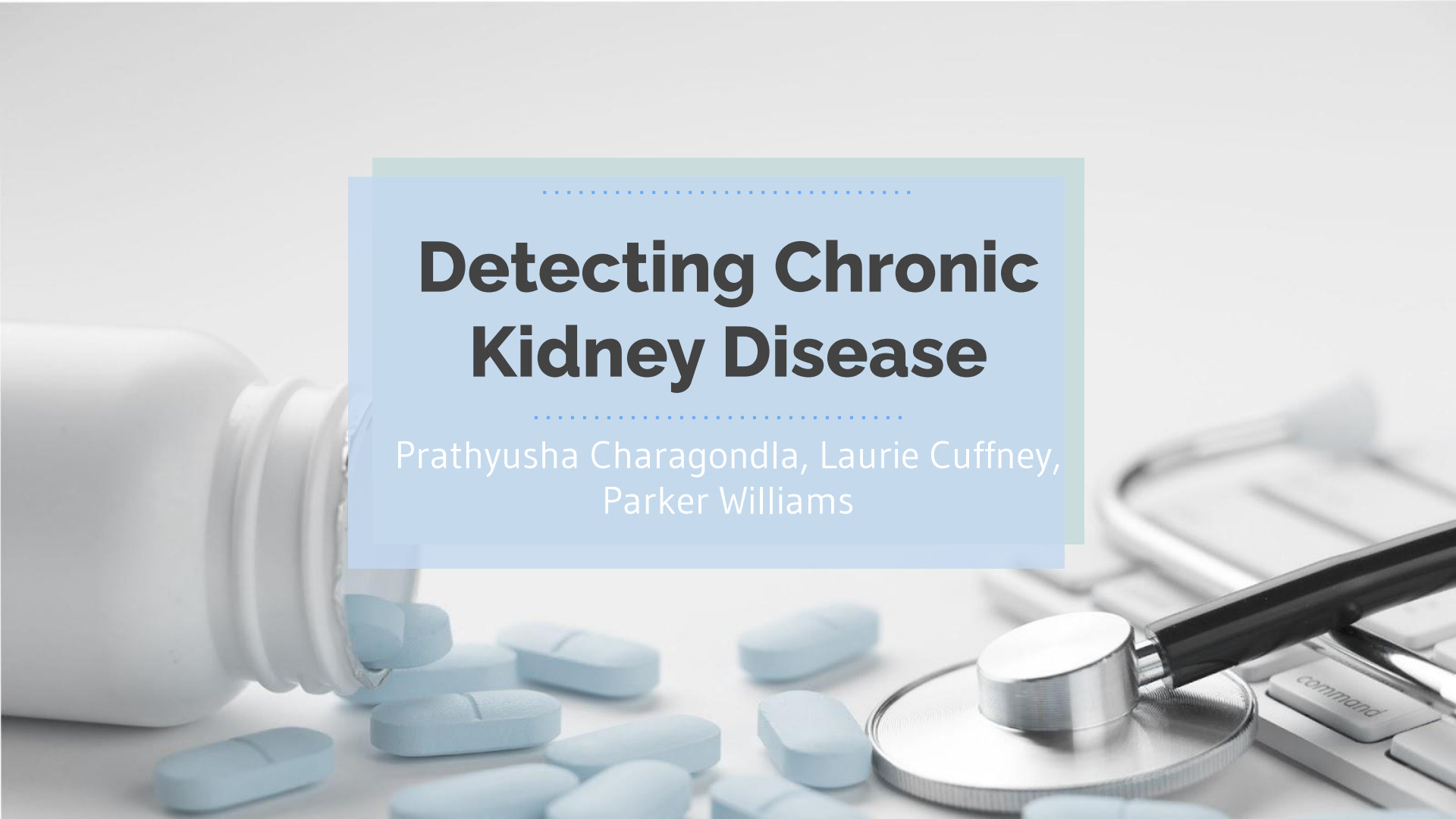
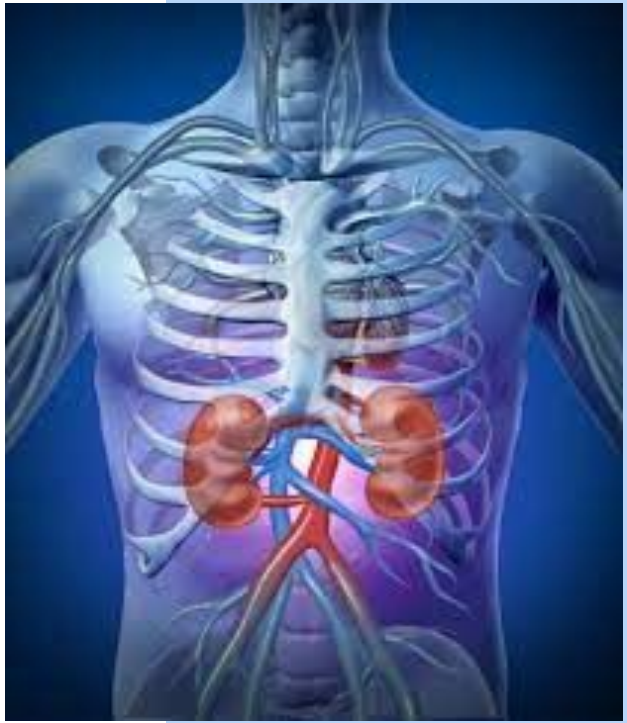
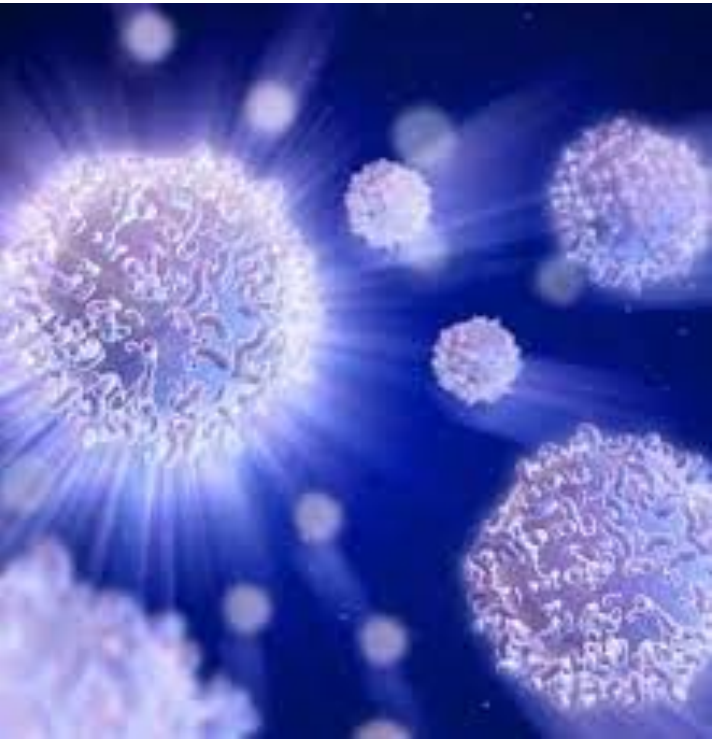


Chronic Kidney Disease (CKD) 'The Silent Disease'

- A diagnosis of kidney disease means that a person's kidneys are damaged and cannot filter blood the way they should.
- Each year, kidney disease kills more people than breast or prostate cancer. In 2013, more than 47,000 Americans died from kidney disease.[1]
- There are 5 stages of kidney disease, but in its early stages and can go undetected until it is very advanced.
- The overall prevalence of CKD in the general population is approximately 14 percent.
- $50 Billion in Medicare was spent on CKD in 2013





The Data

- From UC Irvine Machine Learning Repository.
- Covers a two month period in India
- There 400 observations, 25 features, and a classification variable (Y/N CKD)
- Classification variable: 250 observations CKD=Y and 150 rows CKD=N
- The data includes numeric, binary, and categorical features
- There are just over 1,000 null values across all 25 features.
- The white blood cell count and red blood count variables have the most nulls values with 105 and 130 observations respectively.

Data Preprocessing: Cleaning

Remove Extraneous Tabs

- Several columns read in with extra tab characters
- Causes issues with enumeration

```
labels = data.classification.unique()
labels
```

```
array(['ckd', 'ckd\t', 'notckd'], dtype=object)
```

Correct Data Types

- Three potential numeric feature columns read in as type object
- rc, wc, pcv

```
pcv     object
wc      object
rc      object
```

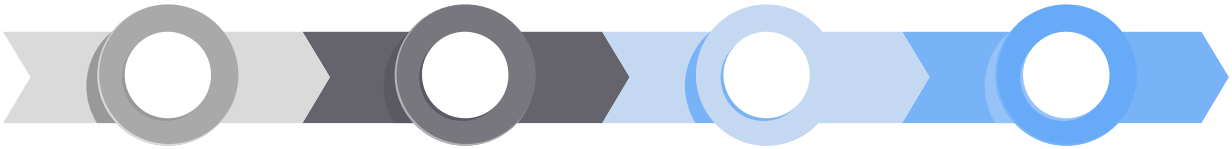
pcv	wc	rc
44	7800	5.2
38	6000	NaN
31	7500	NaN
32	6700	3.9
35	7300	4.6

Additional Data Preprocessing

Binarize Categorical Variables

- 5 yes/no
- 2 abnormal/normal
- 2 present/notpresent
- 1 good/poor

Select features and remove missing values



1: Chronic Kidney Disease
0: Not Chronic Kidney Disease

Recode Class labels

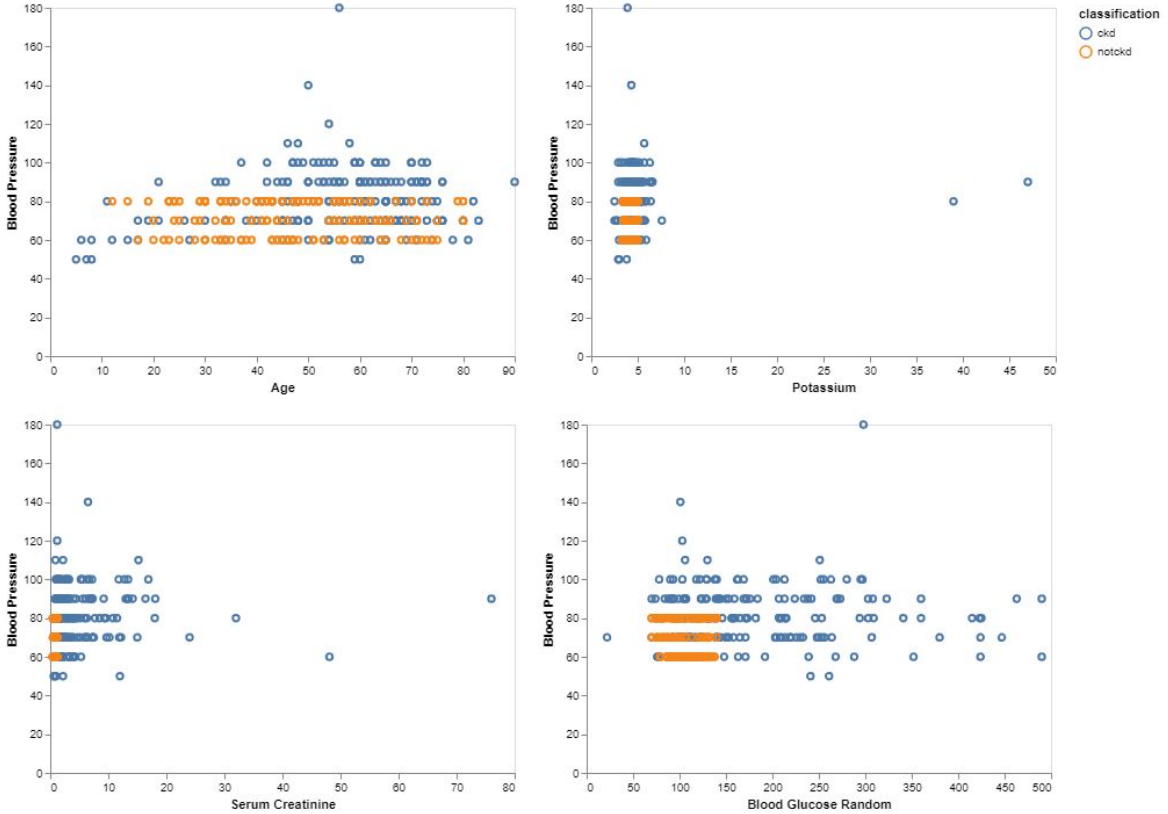
Using sklearn preprocessing.scale( )

Standardize features

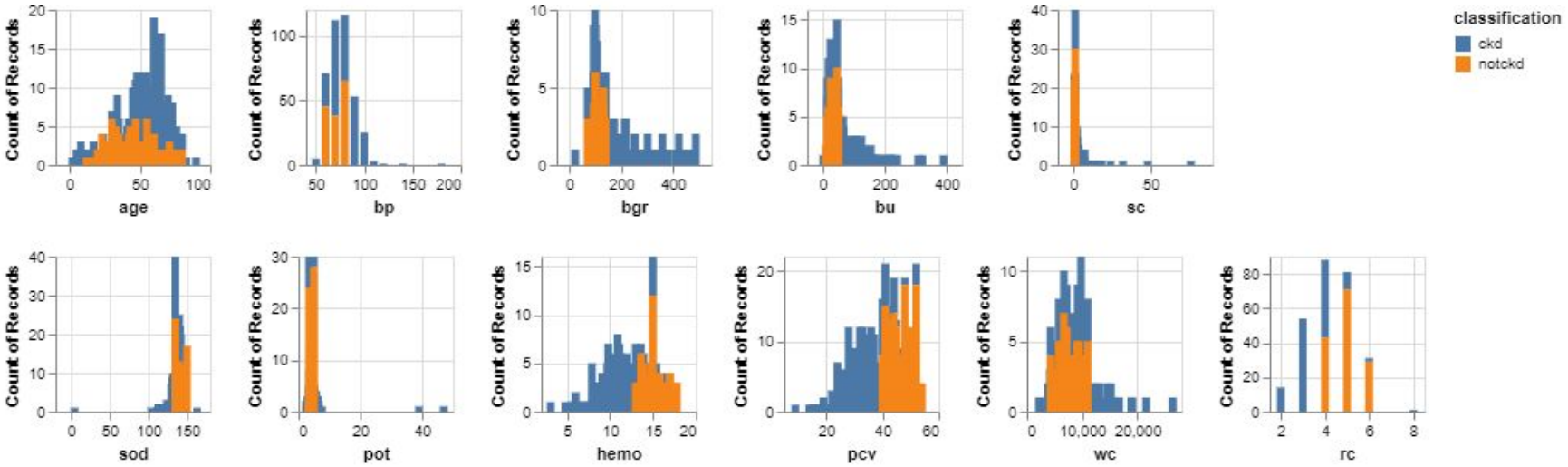
EDA

- Blood pressure vs
  - Age,
  - Potassium
  - Serum Creatinine
  - Blood Glucose Random

- Heavy overlap in between the two classification labels

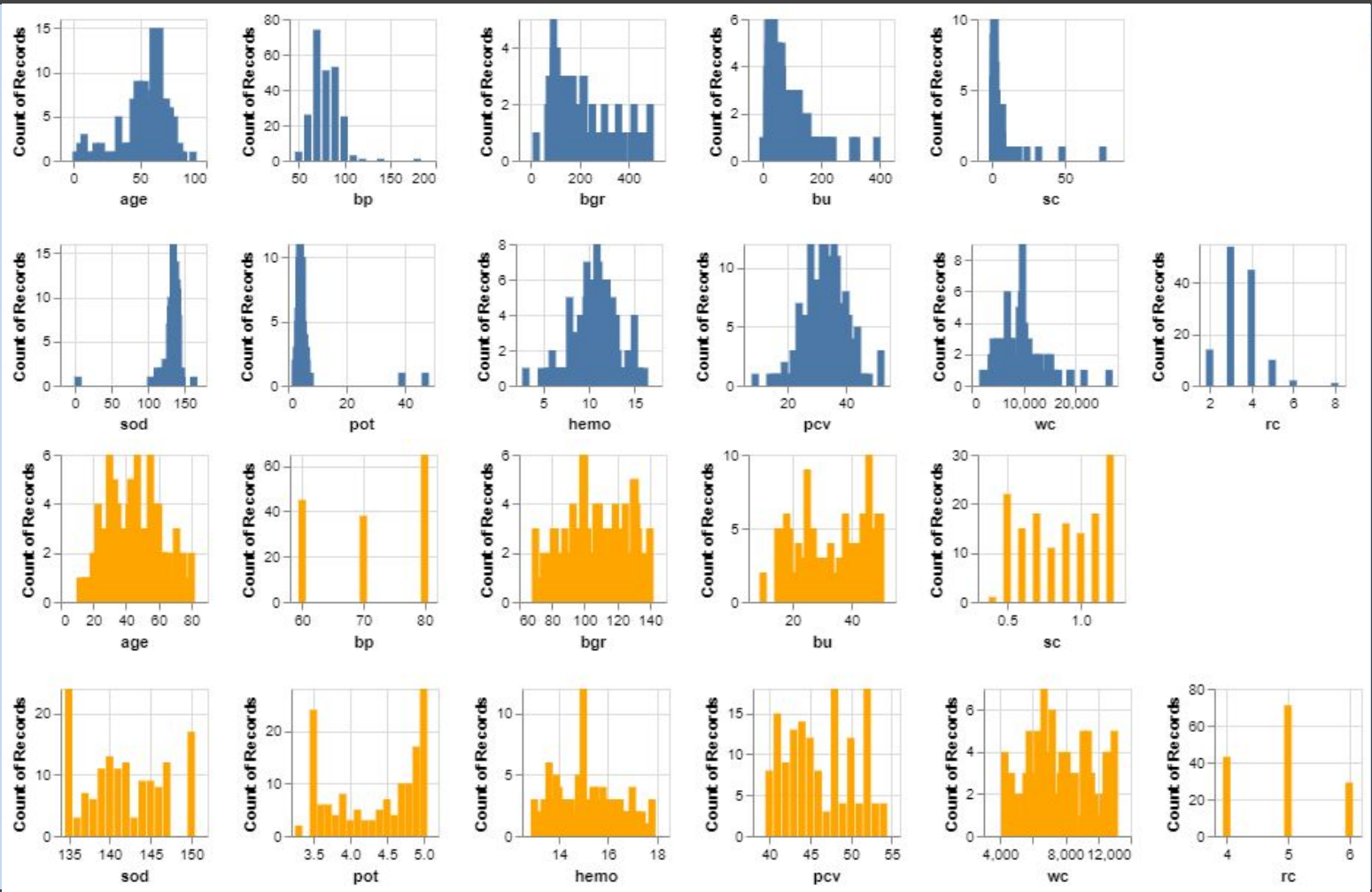


Numeric Feature Variable Distributions



Chronic Kidney Disease

Not Chronic Kidney Disease



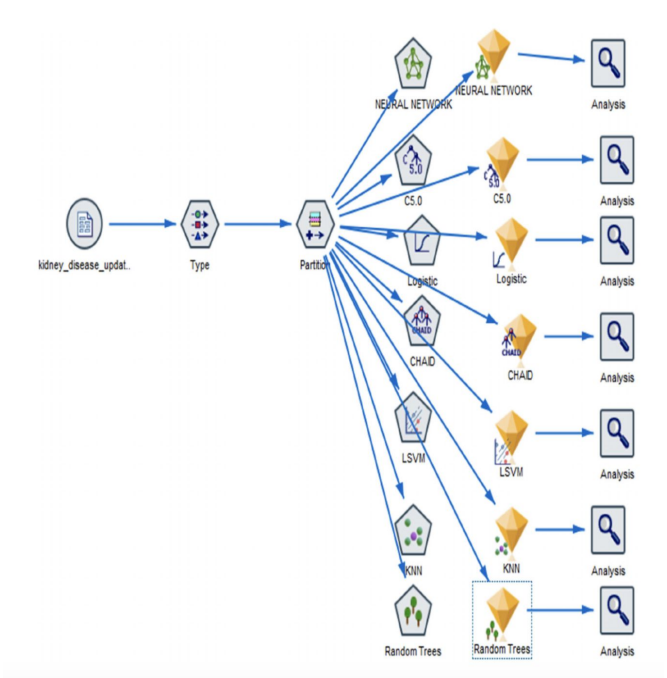


Table 3: Different Algorithm with different number of attribute

Algorithm	Accuracy (25 attributes)	Accuracy (20 attributes)	Accuracy (15 attributes)	Accuracy (10 attributes)
Naïve Bayes	95%	95.5%	96%	95.25%
SVM	97.75%	98.25%	98.5%	97.75%
Decision tree	99%	99%	99%	98%
KNN	95.75%	96	97.5%	96.25%

Literature

- Previously analyzed in multiple papers
- Used to predict/classify instances of Chronic Kidney Disease based on a set of features
- Known models used include: Logistic Regression, KNN, Decision Tree, Naive Bayes, SVM
- On average, both papers found that SVMs performed well (~97% Accuracy between both papers)

1. Chittora, Pankaj & Sandeep, Chaurasia & Chakrabarti, Prasun & Kumawat, Gaurav & Chakrabarti, Tulika & Leonowicz, Zbigniew & Jasiński, Michał & Jasiński, Łukasz & Gono, Radomir & Jasińska, Elżbieta & Bolshev, Vadim. (2021). Prediction of Chronic Kidney Disease - A Machine Learning Perspective. IEEE Access. PP. 1-1. 10.1109/ACCESS.2021.3053763.

2. Tazin, Nusrat & Sabab, Shahed & Chowdhury, Muhammed. (2016). Diagnosis of Chronic Kidney Disease using effective classification and feature selection technique. 1-6. 10.1109/MEDITEC.2016.7835365.

Modeling Components

Features

2 features

- **bp, sc**

16 features

- pc, rbc, htn, cad, ane, su, sg, age, bp, bgr, bu, sc, sod, pot, hemo, pcv

24 features

- All available features

	Number of Features	2	16	24
Train Data	Drop NAs	182	84	77
	Imputed	196(↑8%)	115 (↑37%)	114(↑48%)
Dev Data	Drop NAs	79	36	33
	Imputed	84(↑6%)	50(↑39%)	49(↑48%)
Test Data	Drop NAs	112	52	48
	Imputed	120(↑7%)	71(↑37%)	70(↑46%)

Model: Support Vector Classification

kernel: rbf

$C = 1.0, gamma = 5$

	precision	recall	f1-score	support
0	1.00	0.68	0.81	28
1	0.00	0.00	0.00	0
accuracy			0.68	28
macro avg	0.50	0.34	0.40	28
weighted avg	1.00	0.68	0.81	28

- Initial model has moderately improved accuracy
- Only predicting 0 label (not ckd)

GridSearch CV

Tuning

C = [0.1, 1, 10, 100, 1000]

gamma = [1, 0.1, 0.01, 0.001, 0.0001]

kernel =['linear','rbf']

kernel: linear

$C=0.1, gamma = 1$

	precision	recall	f1-score	support
0	1.00	1.00	1.00	36
1	1.00	1.00	1.00	16
accuracy			1.00	52
macro avg	1.00	1.00	1.00	52
weighted avg	1.00	1.00	1.00	52

- Huge improvement in accuracy on dev data

Model: Support Vector Classification

kernel: linear

$C = 1.0, gamma = 1$

	precision	recall	f1-score	support
0	1.00	0.97	0.99	37
1	0.94	1.00	0.97	15
accuracy			0.98	52
macro avg	0.97	0.99	0.98	52
weighted avg	0.98	0.98	0.98	52

- 98% Accuracy on the test data
- Best SVM model on 16 features

Model: Bernoulli Naive Bayes

Dev Data Performance

	precision	recall	f1-score	support
0	1.00	1.00	1.00	19
1	1.00	1.00	1.00	9
accuracy			1.00	28
macro avg	1.00	1.00	1.00	28
weighted avg	1.00	1.00	1.00	28

- 100% accuracy of the dev data

Test Data Performance

	precision	recall	f1-score	support
0	1.00	0.96	0.98	25
1	0.91	1.00	0.95	10
accuracy			0.97	35
macro avg	0.95	0.98	0.97	35
weighted avg	0.97	0.97	0.97	35

- 97% accuracy on the test data, slightly below the SVM model

Model: Decision Trees

Dev Data
Depth = 5

Prediction Report for Dataset with No Nulls on Dev Data

	precision	recall	f1-score	support
0	1.00	1.00	1.00	19
1	1.00	1.00	1.00	9
accuracy			1.00	28
macro avg	1.00	1.00	1.00	28
weighted avg	1.00	1.00	1.00	28

- Models with 16 variables had around 100% accuracy in Dev and Test

Parameter Tuning

max_depth = [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, None]

Test Data
Depth = 5

Prediction Report for Dataset with No Nulls on Test Data

	precision	recall	f1-score	support
0	1.00	1.00	1.00	24
1	1.00	1.00	1.00	11
accuracy			1.00	35
macro avg	1.00	1.00	1.00	35
weighted avg	1.00	1.00	1.00	35

Model: Ensemble Learning: Bagging

Dev Data
N_Estimators = 500

Prediction Report for Dataset with No Nulls on Dev Data

	precision	recall	f1-score	support
0	1.00	1.00	1.00	19
1	1.00	1.00	1.00	9
accuracy			1.00	28
macro avg	1.00	1.00	1.00	28
weighted avg	1.00	1.00	1.00	28

- Models with 16 variables had around 100% accuracy in Dev and 97% in Test

Parameter Tuning

n_estimators = [10, 50, 100, 500, 1000, 5000]

Test Data
N_Estimators = 500

Prediction Report for Dataset with No Nulls on Test Data

	precision	recall	f1-score	support
0	0.96	1.00	0.98	24
1	1.00	0.91	0.95	11
accuracy			0.97	35
macro avg	0.98	0.95	0.97	35
weighted avg	0.97	0.97	0.97	35

Model: Ensemble Learning: AdaBoost

Dev Data
N_Estimators = 100

Prediction Report for Dataset with No Nulls on Dev Data

	precision	recall	f1-score	support
0	1.00	1.00	1.00	19
1	1.00	1.00	1.00	9
accuracy			1.00	28
macro avg	1.00	1.00	1.00	28
weighted avg	1.00	1.00	1.00	28

- Models with 16 variables had 100% accuracy in Dev and Test

Parameter Tuning

n_estimators = [10, 50, 100, 500, 1000, 5000]

Test Data
N_Estimators = 100

Prediction Report for Dataset with No Nulls on Test Data

	precision	recall	f1-score	support
0	1.00	1.00	1.00	24
1	1.00	1.00	1.00	11
accuracy			1.00	35
macro avg	1.00	1.00	1.00	35
weighted avg	1.00	1.00	1.00	35

Model: Random Forest

Dev Data
criterion = entropy

Prediction Report for Dataset with No Nulls on Dev Data

	precision	recall	f1-score	support
0	1.00	1.00	1.00	19
1	1.00	1.00	1.00	9
accuracy			1.00	28
macro avg	1.00	1.00	1.00	28
weighted avg	1.00	1.00	1.00	28

- Models with 16 variables had around 100% accuracy in Dev and Test

Test Data
criterion = entropy

Prediction Report for Dataset with No Nulls on Test Data

	precision	recall	f1-score	support
0	1.00	1.00	1.00	24
1	1.00	1.00	1.00	11
accuracy			1.00	35
macro avg	1.00	1.00	1.00	35
weighted avg	1.00	1.00	1.00	35

Model: KNN

Dev Data N_Neighbors=1

	precision	recall	f1-score	support
0	1.00	1.00	1.00	19
1	1.00	1.00	1.00	9
accuracy			1.00	28
macro avg	1.00	1.00	1.00	28
weighted avg	1.00	1.00	1.00	28

GridSearch CV

Tuning

n_neighbors = [1,50,1]

Test Data N_Neighbors=1

	precision	recall	f1-score	support
0	0.96	1.00	0.98	24
1	1.00	0.91	0.95	11
accuracy			0.97	35
macro avg	0.98	0.95	0.97	35
weighted avg	0.97	0.97	0.97	35

-

Model: Logistic Regression

Dev Data C=.16

	precision	recall	f1-score	support
0	1.00	1.00	1.00	19
1	1.00	1.00	1.00	9
accuracy			1.00	28
macro avg	1.00	1.00	1.00	28
weighted avg	1.00	1.00	1.00	28

GridSearch CV Tuning

C = [0.1,0.5,0.02]

penalty='l2'

Test Data C=.16

	precision	recall	f1-score	support
0	0.92	1.00	0.96	24
1	1.00	0.82	0.90	11
accuracy			0.94	35
macro avg	0.96	0.91	0.93	35
weighted avg	0.95	0.94	0.94	35

Model Accuracy Overview

	2 features		16 features		24 features	
	Raw	**Imputed**	**Raw**	**Imputed**	**Raw**	**Imputed**
SVM	65%	73%	98%	97%	100%	100%
Naive Bayes	61%	62%	97%	94%	100%	100%
Knn	72%	80%	97%	94%	100%	94%
Logistic	63%	73%	94%	96%	100%	100%
Decision Trees	72%	80%	100%	92%	97%	98%
Random Forest	72%	80%	100%	98%	100%	98%
Bagging	72%	80%	97%	94%	97%	98%
AdaBoost	72%	80%	100%	94%	97%	98%

Conclusion

- Multiple models (KNN, Logistic Regression, SVM, Naive Bayes) had perfect accuracy when we included all features
    - We believe this is due to our limited sample size and lack of variation.
    - This is causing over-fitting which we are benefiting from given our small test holdouts.
    - Accuracy decreases in some of our models when we impute and increase sample size.
- Mean imputation was not beneficial except when using a small number of features.

Thanks!

Does anyone have any questions?

Feel free to share feedback via slack.

Original Unformatted Slides

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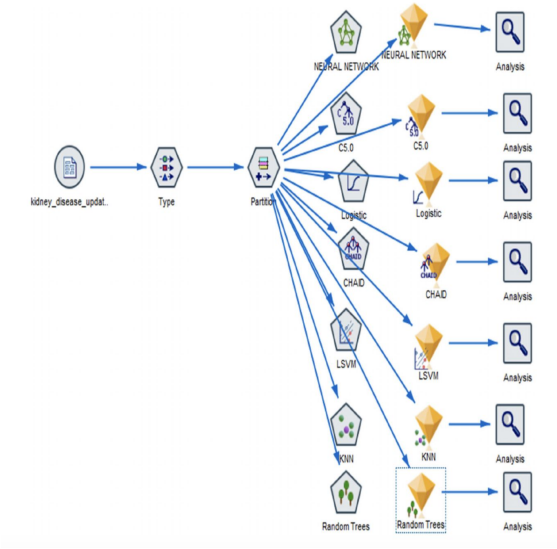

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