

# Prediction, Cross Validation and Classification in the Presence COVID-19 of Indian States and Union Territories using Machine Learning Algorithms

P. Arumugam, V. Kadhiveni, R. Lakshmi Priya, Manimannan G

**Abstract:** The present study predicts, cross validate and classify the data of COVID-19 based on four machine learning algorithm with four major parameters namely confirmed cases, recoveries, deaths and active cases. The secondary sources of database were collected from Ministry of Health and Family Welfare Department (MHFW), from Indian State and Union Territories up to March, 2021. Based on these background, the database classified and predicted various machine learning Algorithm, like SVM, kNN, Random Forest and Logistic Regression. Initially, the k-mean clustering analysis is used to perform and identified five meaningful clusters and is labeled as Very Low, Low, Moderate, High and Very High of four major parameters based on their average values. In addition the five clusters are cross validated using four machine learning algorithm and affected states were visualized with help of prediction and probabilities. The different machine learning models achieved cross validation accuracy of 88%, 97%, 91% and 91%. . Delhi, Uttar Pradesh and West Bengal were Moderately Affected States, Assam, Bihar, Chhattisgarh, Haryana, Gujarat, Madhya Pradesh, Odisha, Punjab, Rajasthan and Telangana are Low Affected States, wherein Tamil Nadu, Kerala, Andhra Pradesh and Karnataka are highly affected States. and Maharashtra the Very Highly Affected State. Rest of the States and Union Territories has Very Low affected Covid-19 Cases is clearly identified.

**Keywords:** COVID-19, Machine Learning Algorithms, Prediction, Cross Validation and Classification.

## I. INTRODUCTION

The COVID-19 pandemic disease caused by SARS-CoV-2 virus and this virus was identified from Wuhan, China in the year 2019. World Health Organization declared world pandemic situation on 11<sup>th</sup> March, 2020, its spread over the world in a short period. Many people were affected by this virus and lost their lives, economy, jobs, Education, etc. In India, the first case is recorded from Kerala and it has spread over the Indian states and union territories. Recently, the second wave of COVID-19 spread is exponentially increasing in all states and union territories. The Indian government launched vaccine camps for the age group of above 45 to upper age people. The vaccine raises immunity in our human bodies and second dosage of vaccine is from 28 to 42 days.

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The main objective of this research paper is to identify the classification and visualization of affected persons using various machine learning and statistical algorithm.

## II. BACKGROUND OF THE STUDY

In Data Mining the KDD (Knowledge Discovery in a Database) is the iterative process that uses to discover novel information and knowledge from large amounts of database. According to Han and Kamber, data mining software allows end-users to analyze data from different dimensions Also, categorize the details and summarize the relationships which are identified during the mining process [1]. Kamber and Han, classification falls into a supervised data mining technique. This process consists of two steps, the first step is learning setup, in which the model is constructed and trained with the help of a predetermined database with class labels. The second step is the place where the trained model is consumed to perform the predictions for given database and measure the accuracy level of the classifier algorithm model [1]. Most of the researches are focusing on behavior of predictive models in data mining (Padmavathi Janardhana). With the help of modern technologies, the researcher can collect a large number of various types of data with different types of parameters in relevant field. Then apply the data mining techniques very correctly and effectively to mine and absorb meaningful interpretations, predictions, etc. when comes to the medical science field, the above said process can be applied to many database like, predicting, classification and visualization of breast cancer, heart attack, oral diseases, diabetes, etc. [2] According to Manimannan G. *et. al.* classification is defined as a process that gives the model to describe and differentiate database classes or concepts to predict the class of objects whose class label is not known. Partitioning clustering algorithm, artificial neural networks, etc. are the major tools used for constructing these models in COVID-19 of Indian States [3]. In recent days, data mining has become an attractive discipline that is used in business, medical science, engineering, text mining and other professional field as well in information technology community. Data mining strategies can provide useful answers to a problem. The methods are Classification, Association, Clustering, Estimation, Novelty detection, sequencing deduction, etc [4] Rajkumar and G.S Reena carried out research using machine learning algorithms (such as K- nearest neighbor, Naive Bayes) for heart disease prediction.



The data set consists of 3000 instances with 14 attributes. Dataset was divided as 70% for training and 30% for testing. According to the test results, Naïve bayes algorithm was selected as the algorithm with better performances when compared with KNN and Decision List [8]. Halgurd S. Maghdid *et al.* have projected a new framework to detect corona virus disease using the inboard smartphone sensors. The designed AI (Artificial Intelligence) framework collects data from various sensors to predict the grade of pneumonia as well as predicting the infection of the disease [6]. The proposed framework takes uploaded CT Scan images as the key method to predict COVID-19 [5] Manimannan G. *et al.* has used Silhouette distance measure for k- means clustering algorithm. It produced effective results and visualized their result in a simple manner. This technique achieved three meaningful groups and is labeled as C1, C2 and C3. C1 represents highly affected, C2 Moderate affected and C1 Low affected States and Union Territories [6].

### III. DATABASE

The secondary source of database was collected from Ministry of Health and Family Welfare Department (MHFWD), from Indian State and Union Territories up to March, 2021 (Table 1). The database consists of four parameters namely confirmed cases, recoveries, deaths and active cases. Initially all parameters are classified using k-means algorithm and additionally tested and cross validated 10 folds stratified sampling methods with help of testing database 10 and training database 60 percent. Subsequently, the machine learning algorithm of kNN, SVM, Random Forest classification and Neural network cross validates the original database and gives better results.

Table 1. Sample Data and Parameters

	CL	State and Union Terr	Cases	Deaths	Recoveries	Active
1	Very Low	Andaman and ...	5028	62	4960	6
2	High	Andhra Pradesh	891004	7177	882763	1064
3	Very Low	Arunachal Prad...	16840	56	16780	4
4	Low	Assam	217726	1096	214997	1633
5	Low	Bihar	262864	1548	261013	303
6	Very Low	Chandigarh	22589	357	21416	816
7	Low	Chhattisgarh	315486	3872	308269	3345
8	Very Low	Dadra and Nag...	3426	2	3404	20
9	Moderate	Delhi	642030	10931	629199	1900
10	Very Low	Goa	55607	802	54130	675
11	Low	Gujarat	275197	4418	267250	3529
12	Low	Haryana	273446	3064	267942	2440
13	Very Low	Himachal Prad...	59347	1003	57745	599
14	Very Low	Jammu and Kas...	127288	1968	124421	899
15	Very Low	Jharkhand	120436	1093	118823	520
16	High	Karnataka	956801	12379	936947	7475
17	High	Kerala	1083530	4342	1043473	35715
18	Very Low	Ladakh	9838	130	9669	39
19	Very Low	Lakshadweep	524	1	355	168
20	Low	Madhya Pradesh	266043	3877	258251	3915
21	Very High	Maharashtra	2252057	52610	2099207	100240
22	Very Low	Manipur	29305	373	28897	35
23	Very Low	Meghalaya	19983	148	19816	19
24	Very Low	Mizoram	4434	10	4415	9
25	Very Low	Nagaland	12217	91	12116	10
26	Low	Odisha	337929	1917	335322	690
27	Very Low	Puducherry	39932	670	39083	179
28	Low	Punjab	192040	5978	176660	9402
29	Low	Rajasthan	322078	2789	317257	2032
30	Very Low	Sikkim	6178	135	5994	49
31	High	Tamil Nadu	856917	12530	840180	4207
32	Low	Telangana	300536	1649	297032	1855

### IV. METHODOLOGY

The following section describes various machine learning Data Mining Algorithms and Workflow (Figure 1):

#### 4.1 k-mean Clustering Algorithm

MacQueen [7] suggests the term k-means for describing an algorithm of his that assigns each item to the cluster having the nearest centroids. The process composed of these three steps:

Step 1: Partition the items (input database) into k-initial clusters.

Step 2: Proceed through the list of items, assigning an item to the cluster whose centroid is nearest (using Euclidean distance measure). Recalculate the centroid for the cluster receiving the new item and for the cluster losing the item.

Step 3: Repeat Step 2 until no more reassignments take place.

#### 4.2 Random Forest Classification Algorithm

Random Forest is a classification technique proposed by Breiman, 2001 [8]. When given a set of class-labeled database, Random Forest builds a set of classification trees. Each tree is developed from a bootstrap sample from the training data. Classification is based on majority vote from individually developed tree classifiers in the forest.

Step 1: Specify the name of the classifier. The default name is "Random Forest Classification".

Step 2: State how many classification trees will be included in the forest, and how many attributes will be arbitrarily drawn for consideration at each node. If the latter is not specified, this number is equal to the square root of the number of attributes in the data.

Step 3: Brieman's proposal is to grow the trees without any pre-pruning, but since pre-pruning often works quite well and is faster, the user can set the depth to which the trees will be grown.

Step 4: Produce a report.

Step 5: Tick Apply to communicate the changes to other widgets. Alternatively, click the box on the left side of the Apply button and changes will be communicated automatically.

#### 4.3 Support Vector Machine (SVM)

Statistical learning aims at gaining knowledge, making predictions, making decisions or constructing model from a set of database, Statistical learning theory gained renewed momentum in data mining after the introduction of SVM developed by Vapnik. *et. al* [9]. The Orange Data mining algorithm presents here:

Step 1: The learner can be given a name under which it will appear in other widgets.

Step 2: Classification type with test error settings. C-SVM and v-SVM are based on different minimization of the error function. On the right side, you can set test error bounds, Cost for C-SVM and Complexity bound for v-SVM.

Step 3: The next block of options deals with kernel, a function that

transforms attribute space to a new feature space to fit the maximum-margin hyperplane, thus allowing the algorithm to create non-linear classifiers with Polynomial, RBF and Sigmoid kernels.

Step 4: Set permitted deviation from the expected value in Numerical Tolerance. Tick the box next to Iteration Limit to set the maximum number of iterations permitted.

Step 5: Produce a report and Click Apply to commit changes.

#### 4.4 k-Nearest Neighbours (k-NN)

This algorithm of k-Nearest Neighbours (k-NN) in statistics is a non-parametric classification method first developed by Evelyn Fix et. al. 1951 [10] and later expanded by Thomas Cover [11]. It is used for classification and regression. In both the cases, input consists of the k closest training examples in data set. The output depends on whether k-NN is used for classification or regression: The Orange kNN algorithm is:

Step 1: A name under which it will appear in other widgets. The default name is "kNN".

Step 2: Set the number of nearest neighbors, the distance parameter and weights as model criteria. In this paper, the researcher used Euclidean distance between two points.

Step 3: The Weights you can use are:Uniform: all points in each neighborhood are weighted equally.

Distance: closer neighbors of a query point have a greater influence than the neighbors further away.

Step 4: Produce a report in the Test and Score window.

#### 4.5 Neural Network Algorithm

McCullough and Walter Pitts first proposed neural network algorithm in the year 1944 [12]. A Multi-Layer Perceptron (MLP) algorithm is used with back propagation in orange data mining:

Step 1: A name under which it will appear in other widgets. The default name is "Neural Network".

Step 2: Set model parameters:

Step 3 Produce a report and the box is ticked (Apply Automatically), the widget will communicate changes automatically.

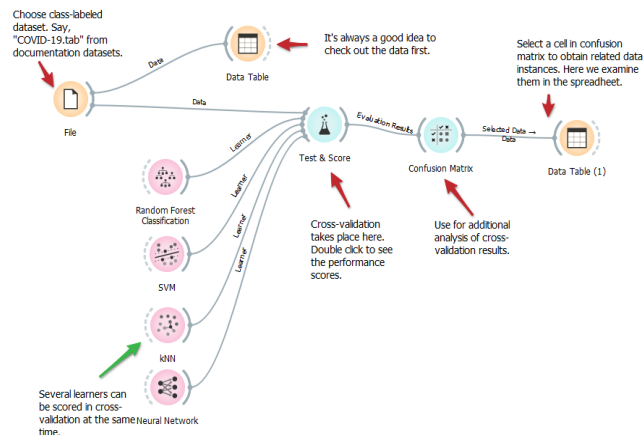


Figure 1. Workflow of various Machine Learning Algorithms

Reddy Prasad suggests a system at his paper to classify the patient with heart disease based on some features. Therefore, the proposed system can predict the presence of heart problems on a person based on the given data. He used logistic regression technology to perform

classification and prediction. Further used sigmoid function for the representation processed [13].

## V. RESULT AND DISCUSSION

The k-means algorithms achieved five meaningful clusters and are labeled as five categories of States and Union Territories of India affected by COVID-19 (Table 2). And also the same result produced the cross validation machine learning algorithm in Table 4 to 7.

Table 2: Final Cluster of k-means Algorithm

	Final Cluster Centers				
	Cluster				
	1 (Low)	2 (High)	3 (Very Low)	4 (Very High)	5 (Moderate)
Conformed Cases	36553.44	947063.00	276334.50	2252057.00	607981.67
Deaths	499.39	9107.00	3020.80	52610.00	9984.67
Recoveries	35794.89	925840.75	270399.30	2099207.00	595758.33
Active Cases	259.17	12115.25	2914.40	100240.00	2238.67
Number of Case in each Cluster	10	4	18	1	3

Table 3 shows the various model accuracy of training data. This is a very high value of accuracy and it is reasonable to expect that the model would be useful to predict new, previously unknown, instance of COVID-19 problem. Rest of the data may be outlier due to data variation in the study period.

The confusion matrix can be used to define a number of performance criteria commonly used in model evaluation suggested by Ali, 2005 [14]. The following section describes various measures of the test score:

#### 5.1 AUC (Area under Curve)

AUC stands for "Area under the ROC Curve." That is, AUC measures the entire two-dimensional area underneath the entire ROC curve from (0,0) to (1,1).

An ROC curve (Receiver Operating characteristic Curve) is a graph showing the performance of a classification model at all classification thresholds. This curve plots two parameter, they are True Positive Rate and False Positive Rate.

True Positive Rate (TPR) is a synonym for recall and is therefore defined as follows:

$$TPR = \frac{TP}{TP + FN}$$

False Positive Rate (FPR) is defined as follows:

$$FPR = \frac{FP}{FP + TN}$$

#### 5.2 Classification Accuracy (CA)

Accuracy is one metric for evaluating classification models. Informally, accuracy is the fraction of predictions and formally has the following definition:

$$Accuracy = \frac{\text{Number of Correct Predictions}}{\text{Total Number of Predictions}}$$



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Accuracy=Number of correct predictions shared by the Total number of predictions. For binary classification, accuracy can also be calculated in terms of positives and negatives as follows:

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

Where TP = True Positives, TN = True Negatives, FP = False Positives, and FN = False Negatives.

## 5.3 F1 Score

The F1 score is calculated by using the following formula:

$$F_1 = 2 * \frac{Precision * Recall}{Precision + Recall} = \frac{2TP}{2TP + FP + FN}$$

## 5.4 Precision

Precision is given by:

$$Precision = \frac{True Positive}{True Positive + False Positive}$$

## 5.5 Recall

Recall Measure is computed by using the formula:

$$Recall = \frac{True Positive}{True Positive + False Negative}$$

The Models of AUC, CA, F1, Precision and Recall measure accuracy value closer to 1 is the best fitted model and closer to 0 is not a good fitted model. In this study all the measures are closer to 1 and these models are best fitted models using machine learning algorithms.

**Table 3: Test Score of Various Algorithm**

Model	AUC	CA	F1	Precision	Recall
kNN	0.967	0.889	0.845	0.816	0.889
SVM Learner	0.956	0.972	0.960	0.950	0.972
Random Forest Learner	0.969	0.917	0.899	0.889	0.917
Neural Network	0.952	0.917	0.900	0.923	0.917

**Table 4: Confusion Matrix of Random Forest Learner**

		Predicted					Σ
		High	Low	Moderate	Very High	Very Low	
Actual	High	50.0 %	25.0 %	25.0 %	0.0 %	0.0 %	4
	Low	0.0 %	100.0 %	0.0 %	0.0 %	0.0 %	10
	Moderate	0.0 %	0.0 %	100.0 %	0.0 %	0.0 %	3
	Very High	100.0 %	0.0 %	0.0 %	0.0 %	0.0 %	1
	Very Low	0.0 %	0.0 %	0.0 %	0.0 %	100.0 %	18
Σ		3	11	4	0	18	36

**Table 5: Confusion Matrix of SVM Learner**

		Predicted					Σ
		High	Low	Moderate	Very High	Very Low	
Actual	High	100.0 %	0.0 %	0.0 %	0.0 %	0.0 %	4
	Low	0.0 %	100.0 %	0.0 %	0.0 %	0.0 %	10
	Moderate	0.0 %	0.0 %	100.0 %	0.0 %	0.0 %	3
	Very High	100.0 %	0.0 %	0.0 %	0.0 %	0.0 %	1
	Very Low	0.0 %	0.0 %	0.0 %	0.0 %	100.0 %	18
Σ		5	10	3	0	18	36

**Table 6. Confusion Matrix of kNN**

		Predicted					Σ
		High	Low	Moderate	Very High	Very Low	
Actual	High	100.0 %	0.0 %	0.0 %	0.0 %	0.0 %	4
	Low	0.0 %	100.0 %	0.0 %	0.0 %	0.0 %	10
	Moderate	66.7 %	33.3 %	0.0 %	0.0 %	0.0 %	3
	Very High	100.0 %	0.0 %	0.0 %	0.0 %	0.0 %	1
	Very Low	0.0 %	0.0 %	0.0 %	0.0 %	100.0 %	18
Σ		7	11	0	0	18	36

**Table 7. Confusion Matrix of Neural Network**

		Predicted					Σ
		High	Low	Moderate	Very High	Very Low	
Actual	High	100.0 %	0.0 %	0.0 %	0.0 %	0.0 %	4
	Low	0.0 %	100.0 %	0.0 %	0.0 %	0.0 %	10
	Moderate	66.7 %	0.0 %	33.3 %	0.0 %	0.0 %	3
	Very High	100.0 %	0.0 %	0.0 %	0.0 %	0.0 %	1
	Very Low	0.0 %	0.0 %	0.0 %	0.0 %	100.0 %	18
Σ		7	10	1	0	18	36

**Table 8. Prediction and Probabilities of States and Union Territories**

CL	and Union Territ	Classif Learner	gHight	gLow	gModerate	gVery High	gVery Low	Cases	Deaths	Recovery	Active
1	Very Low	Andhra Pradesh	0.919684	0.917781	0.917989	0.917989	0.917989	12124	52	45024	8
2	Very Low	Assam	0.917311	0.916240	0.917407	0.917405	0.917408	16440	56	16730	4
3	Low	Bihar	0.916605	0.91762	0.917513	0.916602	0.917580	12146	284	28742	240
4	High	Chhattisgarh	0.916596	0.916824	0.917554	0.916532	0.916449	9381	1337	10426	210
5	Very Low	Goa	0.916079	0.917649	0.916988	0.916975	0.916975	13325	442	13442	215
6	High	Kerala	0.91678	0.916989	0.916788	0.916788	0.916788	524	177	282	363
7	Very Low	Ladakh	0.915778	0.916823	0.917123	0.917123	0.916747	1	0	1	1
8	Low	Rajasthan	0.916481	0.916811	0.916828	0.916817	0.916811	46378	678	46137	261
9	Low	Uttarakhand	0.916783	0.916214	0.916456	0.916456	0.916214	10944	249	10715	261
10	Very Low	West Bengal	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
11	Very Low	Madhya Pradesh	0.916289	0.916456	0.917167	0.916456	0.916456	4424	19	4415	9
12	Moderate	Odisha	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
13	Low	Uttar Pradesh	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
14	Very Low	West Bengal	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
15	Very Low	West Bengal	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
16	Moderate	West Bengal	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
17	Very Low	West Bengal	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
18	Moderate	West Bengal	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
19	Low	Madhya Pradesh	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
20	Very Low	Madhya Pradesh	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
21	Very Low	Madhya Pradesh	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
22	Very Low	Madhya Pradesh	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
23	Very Low	Madhya Pradesh	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
24	Very Low	Madhya Pradesh	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
25	Very Low	Madhya Pradesh	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
26	Very Low	Madhya Pradesh	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
27	Very Low	Madhya Pradesh	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
28	Very Low	Madhya Pradesh	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
29	Very Low	Madhya Pradesh	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1
30	Very Low	Madhya Pradesh	0.916181	0.916811	0.916811	0.916811	0.916811	1254	1	1254	1

Based on the above models, Machine Learning algorithm achieved better prediction and proximities in all the methods. On the whole ten percentages of prediction and proximities are misclassified due to different models and noisy data. The different machine learning models cross validation and classification accuracy are 88%, 97%, 91% and 91%. The Classification of States and Union Territories were named as Very Low Affected (VLA), Low Affected (LA), Moderately Affected (MA), Highly Affected (HA) and Very Highly Affected (VHA) States and Union Territories of India by COVID-19 cases.



Maharashtra is correctly classified as Very High Affected States, Delhi, Uttar Pradesh and West Bengal falls in Moderately Affected States, Assam, Bihar, Chattisgarh, Haryana, Gujarat, Madhya Pradesh, Odisha, Punjab, Rajasthan and Telangana falls in Low Affected States, and Tamilnadu, Kerala Andhra Pradesh and Karnataka forms a group of highly affected States. Remaining States and Union Territories falls in Very Low affected by Covid-19 Cases (Table 8). The second wave of COVID-19 also started from March 2021. The government is taking necessary action to prevent and control the spread of COVID. Also our government advices our people to take vaccination over and above 45 years of age.

## VI. CONCLUSION

In this section the researcher predicts and classifies the data of COVID-19 based on four machine learning algorithm with four major parameters namely confirmed cases, recoveries, deaths and active cases. The secondary sources of database were collected from Ministry of Health and Family Welfare Department (MHFW), from Indian State and Union Territories up to March, 2021. Based on these background, the database classified and predicted various machine learning Algorithm, like SVM, kNN, Random Forest and Logistic Regression. Initially, k-means clustering analysis is used to perform and identified five meaningful clusters and is labeled as Very Low, Low, Moderate, High and Very High of four major parameters based on their average values. In addition the five clusters are cross validated using four machine algorithm and affected states are visualized in the table with help of prediction and probabilities. The different machine learning models cross validation and classification accuracy are 88%, 97%, 91% and 91%. The Classification of States and Union Territories were named as Very Low Affected (VLA), Low Affected (LA), Moderately Affected (MA), Highly Affected (HA) and Very Highly Affected (VHA) States and Union Territories of India by COVID-19 cases. Maharashtra is correctly classified as Very High Affected States, Delhi, Uttar Pradesh and West Bengal falls in Moderately Affected States, Assam, Bihar, Chattisgarh, Haryana, Gujarat, Madhya Pradesh, Odisha, Punjab, Rajasthan and Telangana falls in Low Affected States and Tamilnadu, Kerala Andhra Pradesh and Karnataka forms a group of highly affected States. Remaining States and Union Territories falls in Very Low affected by Covid-19 Cases (Table 8).

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