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A Supervised Learning Algorithm to Forecast Weather Conditions for Playing Cricket

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Abstract*: Now days, Machine learning is considered as the key technique in the field of technologies, such as, Internet of things (IOT), Cloud computing, Big data and Artificial Intelligence etc. As technology enhances, lots of incorrect and redundant data are collected from these fields. To make use of these data for a meaningful purpose, we have to apply mining or classification technique in the real world. In this paper, we have proposed two nobel approaches towards data classification by using supervised learning algorithm

Keywords: Machine learning, Classification, Supervised learning.

I. INTRODUCTION

After appearing the first edition of machine learning in 2004 [7], it became the favourite target of researchers and scientists throughout the world. It has turned pace and direction of technology towards a new world, in which search engine, recommendation system and spam filtering were the most innovative inventions of machine leaning [7]. It has also affected the computational biology in the field of natural language processing, whose invention was machine translation. It affected almost all the fields such as robotics, medical diagnosis etc [5,18]. Earlier, an algorithm was considered as a fuel to solve a computer related problem [8]. An Algorithm consist of sequence of instructions which gives output based on input data. There may be more than one algorithm exists for the same problem but we consider an algorithm with less time and space complexity. Sometimes, there is a case, in which no existing algorithm can be applied for a particular problem for example, spam filtering problem, in spam filtering problem, a generalized algorithm can not be written because, spam messages vary from individual to individuals.

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We know input of the problem is set of emails and output is yes/no, if message is spam then yes otherwise no. But, we do not know the method (algorithm) of transforming input data into output. In this situation, machine should automatically extract the algorithm from the past experience of user i.e. called machine learning [7,18]. Over the last few years, Machine learning is spreading its arms in Industry, Enterprise world and Academia. In industry, Machine learning is a data processing tool for securely process the data over the distributed network without having any pre-programming concept. In enterprise world, machine learning is widely used in enhancing the relation between producer and consumers [5]. Machine learning projects the clear and quick picture of current market demand. In academia, it is a tool or driving force for radically shaping the economy and the society in the centralized world. Machine learning with artificial intelligence is widely used in autonomous devices such that autonomous car, robots etc [6].

Machine learning is a subset of artificial intelligence where computers algorithms used to learn autonomously from the information. Today, machine learning is enabling the computers to interact with humans [5]. It gives the tremendous effect in fields like pattern recognition [12], image processing in cognitive science [2], data mining [14]and data clustering [14]. For use of machine learning, it needs huge amount of historical and practical dataset for processing different activities in the field of pattern recognition, image processing in cognitive science, data mining and data clustering.

II. MOTIVATION AND CONTRIBUTION

The reason behind to predict the weather conditions is to plan many human activities like agriculture, nature disaster prevention ,plan daily activities and so on. Across the world meteorologist face the challenge in accuracy of weather analysis and prediction[21]. On the other hand researchers had tried to predict different metrological parameters like wind speed, air pressure, humidity, temperature by utilizing different data mining techniques[23]. In this paper we have a taken the application of predicting weather conditions to play cricket as it plays a major role the gaming process.

Most of the machine learning algorithms are based on data classification techniques. Data classification is a process of classifying similar type of objects from the dataset and grouping them together to predict desired output [15]. This process requires pre-processing of data in which feature selection is most difficult task. Feature selection is the process of finding out as much relevant and unique features as possible.

Pre-processing of data helps data mining algorithms to operate accurately on dataset. But, to a little extant, features dependency on one another remains in dataset that leads to affect the performance of machine learning algorithm.
That is the reason, naive bayes classification technique is being used here that works surprisingly well even though there is a dependency among features because it makes a strong assumption of independency among features. This paper describes a classification technique which is simplest among all techniques i.e. Naive byes classification.
Naive byes is a supervised learning approach which uses past information about data and design a new model which is used to predict outcomes for new dataset. First time this classification was proposed by Thomas Bayes (1702-1761) [4]. The rest of the paper is structured as mentioned. Section 1 describes the machine learning methodologies. In section 2, presents the literature survey related to supervised, unsupervised, semi supervised and reinforcement learning algorithms. Next, we discussed the proposed work in section 3. Finally, we conclude the paper with future work.

III. LITERATURE SURVEY

In 1950, Alan Turing [1] had tried to test "is computer has real intelligence" in the test, computer has to make fool to a man considering itself as a human. Since that time, A handful of work has been done in this field of computation. Number of theorems, algorithms has been proposed by the researchers in the last few years such as support vector machine, k-nearest algorithm, decision tree algorithm etc. Mostly machine learning algorithms are used in advance technology like robotics, brain decoding, artificial intelligence, natural language processing (NLP) etc. Machine learning Algorithms are classified into four main categories which are Supervised learning, Unsupervised learning, Semi-supervised learning and Reinforcement learning algorithms. Little amount of work has been done in these fields therefore, there are some useful extractions are remaining to be extracted.

A. Supervised Learning

Supervised learning is a tool of machine learning in which a function is trained based on existing training data examples. Supervised learning algorithms needs lot of labelled data to predict desired outcome. Labelled data comprised of both input and its corresponding outputs. Supervised learning algorithms learns from labelled data and predicts the output based on labelled data. Supervised learning is widely used in data mining (extracting useful information from huge dataset) and email spam filtering (automatic removing of spammed messages) [17].

B. Unsupervised Learning

Unsupervised learning has dragged a lot of attention of the researchers by its ability of predicting efficient output without any labelled data. Unsupervised learning is tool of machine learning where it tries to recognize a pattern in data without any prior knowledge about data, like grouping the people who have age less than sixteen years as teenager and as adults who have age more than sixteen years. There are some classical problems which can be solved by unsupervised learning algorithms which are Clustering, Association, Anomaly detection etc [13]. After pre-processing of data, an unsupervised learning algorithm is used to discover the features from unlabelled data by using different methodologies such that Sparse auto encoders, K-means clustering etc [3].

C. Semi-supervised Learning

Semi-supervised learning algorithm consist of both supervised and unsupervised learning. semi-supervised learning algorithm approach is based on Gaussian random field model. Data which can be labelled or unlabelled can be represented as a weighted graph where edge weight encoded the similarity between the instances. In very few cases, it uses labelled data to predict outcomes. in most of the cases it solves the problems which are the extensions of supervised or unsupervised classical problems [20].

D. Reinforcement Learning

In recent years, Reinforcement learning has got tremendous fame because of its success in its theoretical aspect therefore; researchers are getting attracted to implement its functionality in practice. Reinforcement learning starts from small amount of data which may not be sufficient for correct prediction but it learns from that data over a period of time and improves its efficiency of outcome prediction [6]. This algorithm is not used frequently because it is time taking algorithm but in near future, this technique will extremely change the aspect of looking into the world. Expected areas which can be explored by reinforcement learning may be 'time and space', neural networks, brain decoding etc [18].

IV. PROPOSED WORK

In this paper, we are discussing about a classical problem of supervised learning i.e. **classification**. classification is a process of grouping same class entities into one class. It may be binary classification or multi-label classification. Binary classification suggest only two discrete values like, will it rain tomorrow (yes / no). Multi-label classification example is differentiating similar types of photos by their categories [10]. We have mainly three classifiers techniques which are widely used which are Gaussian naive byes algorithm, K-nearest neighbour algorithm and support vector machine algorithm [11,16]. But in this regard, we will strongly focus on Gaussian naive byes algorithm.

A. Naive Bayes algorithm

In machine learning study, concentration is always focused on best hypothesis based on given input data. Hypothesis is a prediction of an event based on certain circumstances. Hypothesis can be used as a class for new instance of data in classification problems [16]. Most probable hypothesis can be concluded based on our prior knowledge about the problem statement. Bayes' theorem is based on this theory. It chooses the best hypothesis based on its existing knowledge about problem dataset and predicts the best hypothesis [9,11].

B. Bayes theorem

Bayes theorem calculate the probability of occurring an event provided with the probability of similar kind of event that has already occurred.Bayes theorem can be mathematically stated as shown in equation 1:

$$p(x|y) = \frac{p(y|x) * p(x)}{p(y)} \quad (1)$$

Where x and y are two events.

- Here, calculating probability of event x provided with event y is always true.
- $p(x)$ is prior probability of event x that has already occurred.

$p(x|y)$ is called as a posterior probability which we are interested to calculate. Posterior probability can be calculated for a number of different hypothesis. Best hypothesis can be choosed with highest probability among all.

This is formally called as MAP (maximum a posteriori).It can be mathematically stated as:

$$MAP(x) = MAX(p(x|y) \quad (2)$$

Or

$$MAP(x) = MAX\left(\frac{p(y|x) * p(x)}{p(y)}\right) \quad (3)$$

Term $p(y)$ can be drooped as it is only used for normalization, it can be assumed as a constant. Finally, we have

$$MAP(x) = MAX\left(p(y|x) * p(x)\right) \quad (4)$$

C. Assumption

A very strong and simple assumption has been made about naive Bayes is that "all the features of a given data set are independent and has equal participation in outcome". While designing any model of machine learning, features selection is tedious task. Features are small but useful information which is taken from the given dataset [6,7]. For example, Consider the classification for education domain where some features could be institute, courses, country etc.

Naive Bayes assumptions are generally not popularly used in real world applications. Although, they give best output in practice, like in data mining.

D. Block Diagram representation of naive byes

Here, In Fig.1. block diagram shown below, it is clearly explained, how data is classified in to two parts (data features and training data). Both the parts of data are provided to naive byes algorithm whose output is provided to the training classifier which is tasted based on testing dataset. Then, it computes the result (output or prediction).

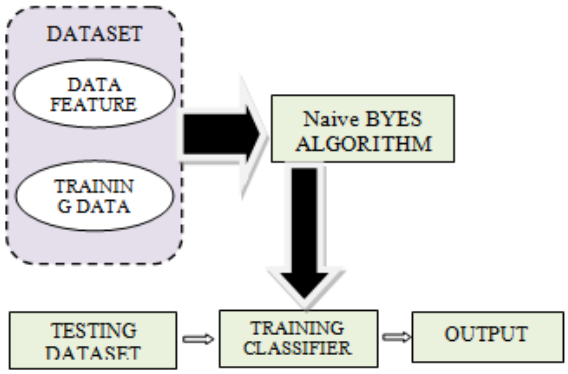

Fig.1. Block diagram representation of naive byes.

E. Case Study

Here, in the table, shown below, we have described the data about weather forecast conditions for a cricket game**.** Based on the parameters (outer vision, climate, dew, air), it would be decided that cricket game will be played or not.

Table 1. Weather Dataset.

Day	Outer vision	Climate	Dew	Air	Play Cricket
1	Rainy	Hot	High	Slow	No
2	Rainy	Hot	High	Fast	No
3	Sunny	Hot	Normal	Slow	No
4	Overcast	Mild	High	Fast	Yes
5	Sunny	Cool	Normal	Slow	Yes
6	Overcast	Cool	Normal	Fast	No
7	Rainy	Mild	High	Slow	Yes
8	Overcast	Hot	Normal	Slow	No

Hence, above dataset is classified into two categories which are **feature grid** and **class variable**. Feature grid can be described as, rows which contains the value of dependent variable in the dataset. With regards of our dataset, feature grid will be 'outer vision', 'climate', 'dew' and 'air'. Class variable can be described as prediction(outcome) in dataset. With regards of our dataset, class variable is 'play cricket'.

We can write naive byes for our dataset,

$$p(A|B) = \frac{p(B|A) * p(A)}{p(B)} \quad (5)$$

Where, A is class variable and B is feature grid of size n.

$$B = (b1, b2, b3 \ldots\ldots\ldots\ldots bn) \quad (6)$$

Let's take an example from our dataset,

$$B = (Rainy, hot, high, slow)$$

$$A = (NO)$$

It represents probability of playing cricket is no when weather conditions are such type as described above in set B.

Probability of any two independent variable is multiple of both probabilities as

$$p(x, y) = p(x) * p(y) \quad (7)$$

Therefore,

$$p(A|b1, b2, b3 \ldots\ldots bn) = \frac{p(b1|A) * p(b2|A) * p(b3|A) \ldots\ldots p(bn|A) * p(A)}{p(b1) * p(b2) * p(b3) \ldots\ldots p(bn)} \quad (8)$$

Or,

$$p(A|b1, b2, b3 \ldots\ldots bn) = \frac{p(A) * \prod_{i=1}^{n} p(bi|A)}{\prod_{i=1}^{n} p(b)} \quad (9)$$

For a given set of inputs, denominator remains constant therefore we can state above expression as

$$p(A|b1, b2, b3 \ldots\ldots bn) = p(A) * \prod_{i=1}^{n} p(bi|A) \quad (10)$$

After getting this above expression, we are left with only probabilities values for every set of input of class variable and hence we will choose hypothesis with maximum probability value.Finally, we have

$$A = MAX\left[p(A) * \prod_{i=1}^{n} p(bi|A))\right] \quad (11)$$

Therefore, we have to find out $p(A)$ and $p(bi|A)$

Where $p(A)$ and $p(bi|A)$ are termed as **class** and **conditional** probabilities values respectively. Some pre-calculations are required to find out these (class and conditional) probabilities which are $p(bi|aj)$ for every $bi\ in\ B$ and $aj\ in\ A$. We have calculated below in tables.

Table 2. Contains probability about outer vision data.

	Yes	No	P(yes)	P(no)
Rainy	1	2	1/5	2/4
Overcast	1	2	1/5	2/4
Sunny	3	0	3/5	0/4
Total	**5**	**4**	**100%**	**100%**

Table 3. Contains probability of climate.

	Yes	No	P(yes)	P(no)
Hot	1	3	1/5	¾
Mild	3	0	3/5	0/4
Cool	1	1	1/5	¼
Total	**5**	**4**	**100%**	**100%**

Table 4. Contains probability about dew.

	Yes	No	P(yes)	P(no)
High	3	2	3/5	2/4
Normal	2	2	2/5	2/4
Total	**5**	**4**	**100%**	**100%**

Table 5. Contains probability about air.

	Yes	No	P(yes)	P(no)
Fast	2	2	2/5	2/4
Slow	3	2	3/5	2/4
Total	**5**	**4**	**100%**	**100%**

Table 6. Contains probability of playing cricket.

Play cricket	Total no of yes/no	Prob of yes/no
Yes	5	5/9
No	4	4/9
Total	**9**	**100%**

In above tables, we have found out $p(bi|aj)$ for each bi in B and aj in A. for example P (dew=high | play cricket=yes) =3/5 (probability of playing cricket) with given condition. Features probability has been calculated in 2-5 tables and class probability has been calculated in table. 6 For ex: P (play cricket=no) =4/9.

Now, we have calculated all probabilities called pre-calculations and the classifier is ready to predict the outcomes.

Test this classifier on new set of data called 'newest'.

$$newset = (rainy, cool, normal, fast)$$

Probability of playing cricket will be calculated as:

$$\begin{aligned} p(yes|newset) &= p(outer\ vision = rainy|play\ cricket = yes) \\ &* p(climate = cool|play\ cricket = yes) \\ &* p(dew = normal|play\ cricket = yes) \\ &* p(air = fast|play\ cricket = yes) \\ &* \frac{p(yes)}{p(newset)} \end{aligned} \quad (12)$$

Probability of not playing cricket will be calculated as:

$$\begin{aligned} p(no|newset) &= p(outer\ vision = rainy|play\ cricket = no) \\ &* p(climate = cool|play\ cricket = no) \\ &* p(dew = normal|play\ cricket = no) \\ &* p(air = fast|play\ cricket = no) \\ &* \frac{p(no)}{p(newset)} \end{aligned} \quad (13)$$

Since, $p(newset)$ have same value in both cases, therefore, we can drop $p(newset)$.

Hence,

$$p(yes|newset) = \frac{1}{5} \times \frac{1}{5} \times \frac{2}{5} \times \frac{2}{5} \times \frac{5}{9} \approx 0.00556$$

And

$$p(no|newset) = \frac{2}{4} \times \frac{1}{4} \times \frac{2}{4} \times \frac{2}{4} \times \frac{4}{9} \approx 0.01388$$

By the method of normalization, sum of probabilities is 1.

So,

$$p(yes|newset) + p(no|newset) = 1 \quad (14)$$

Calculate the probability of playing cricket:

$$p(yes|newset) = \frac{0.00556}{0.00556 + 0.01388} = 0.289$$

Calculate the probability of not playing cricket:

$$p(no|newset) = \frac{0.01388}{0.00556 + 0.01388} = 0.7139$$

Finally, we got the probabilities of both cases.Since,

$$p(no|newset) > p(yes|newset)$$

Prediction that is made by classifier is 'no' which suggests, with the given conditions, you cannot play cricket.

V. GAUSSIAN NAIVE BAYES CLASSIFIER

We assume, all continuous values which are associated with each feature in dataset are distributed according to gaussian distribution.by assuming the gaussian distribution, naïve byes can be extended to real valued attributes. This extension is called gaussian naïve Bayes. There are n – number of functions are available for estimating the distribution of data, but Gaussian distribution is easiest among all because, it need only mean and standard deviation from the given set of data. Above, probabilities of each input for each class has been calculated. similarly, we have to calculate mean and standard deviation.

Mean can be calculated as:

$$Mean(X) = \frac{sum(X)}{n} \quad (15)$$

Where, X are the values for an input variable in dataset and n is the number of instances. Standard deviation can be calculated as:

$$standard\ deviation = \sqrt{\frac{sum(Xi - mean(x)^2}{n}} \quad (16)$$

Where, Xi is the value of X variable at ith instance.

After calculating Mean and standard deviation, we can calculate conditional probability which is given by:

$$p(Xi|y) = \frac{1}{\sqrt{2\pi\sigma_y^2}} \exp\left(-\frac{(x_i - \mu_y)^2}{2\sigma_y^2}\right) \quad (17)$$

Where, σ_y^2 and μ_y are standard deviation and mean respectively.

Gaussian distribution is symmetric about its mean and gives a bell-shaped curv when it is plotted (See Fig.2).

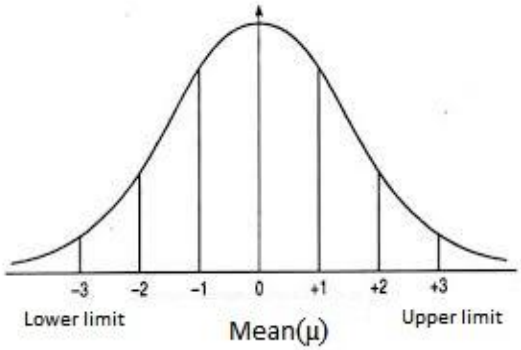

Fig.2. Gaussian (Normal) distribution curve of probability.

A. Case Study

Here, in the table shown below, we have described about sample data set which contains three parameters those are 'hair length', 'height', 'weight'. Based on these three parameters we will try to design a classifier which can predict about new dataset by using gaussian naive byes.

Table 7. Sample dataset.

Gender	Hair length (c.m)	Height(feet)	Weight(lbs)
M	5	5.83	180
M	6	5.72	160
F	8	5.12	130
M	4	6.13	190
M	4.5	5.94	185
F	9	4.95	120
F	7	5	135
F	6.5	5.3	140

Now, we will train a classifier based on above data. We will find out mean and variance of each input for each class (parameter).

Table 8. calculated values for 'hair length' parameter.

Gender	Mean	Variance
M	4.875	0.546875
F	7.625	0.921875

Table 9. calculated values for 'height' parameter.

Gender	Mean	Variance
M	5.905	0.022925
F	5.09	0.018175

Table 10. calculated values for 'weight' parameter.

Gender	Mean	Variance
M	178.75	129.6875
F	131.25	54.6875

Assume, we have equal prior probability distribution $p(M) = p(F)$=0.5. this distribution can be based on our prior knowledge of sample data in large population.After calculation of mean and variance of each input for every class, we will take a new data set and try to find out weather our trained classifier is working properly or not.

Sample dataset is shown below in Table11, which has to be classified into male or female.

Table 11. Sample data to test classifier.

Gender	Hair length	Height	Weight
Sample	6.3	5.5	150

We have to calculate posterior probability of M (male) and F (female) and then compare which posterior probability is greater.

Posterior probability of M(male) is given by,

$$posterior(M) = \frac{p(M) * p(hair\ length|M) * p(height|M) * p(weight|M)}{p(sample)}$$

Posterior probability of F(female) is given by,

$$posterior(F) = \frac{p(F) * p(hair\ length|F) * p(height|F) * p(weight|F)}{p(sample)} \quad (19)$$

P(sample) can be assumed as a normalizing constant, thus scales both probabilities equally. Therefore, we can simply ignore (drop) the term *p(sample).*

Now, we will calculate probability distribution for sample

$$p(Xi|y) = \frac{1}{\sqrt{2\pi\sigma_y^2}} \exp\left(-\frac{(x_i - \mu_y)^2}{2\sigma_y^2}\right) \quad (20)$$

B. Posterior probability of M (male)

We have calculated all values by using equation (20)

P (hair length |M) =0.084272
P (height |M) =0.073637
P (weight |M) =1.44×10^{-3}
P(M)=0.5
Posterior probability of M(male)

$$posterior(M) = 0.5 * 0.084272 * 0.073637 * 1.44 \times 10^{-3} = \mathbf{4.4679 \times 10^{-6}}$$

C. Posterior probability of F(Female)

We have calculated all values by using equation (20)
P (hair length |F) =0.099214786
P (height | F) =0.589297
P (weight |F) =2.1678×10^{-3}
Posterior probability of F(Female)

$$posterior(F) = 0.5 * 0.099214786 * 0.589297 * 2.1678 \times 10^{-3} = \mathbf{6.3371 \times 10^{-5}}$$

Here, we have calculated both posterior probability of male and female and now we have to compare both.

Finally,

$$posterior(F) > posterior(M)$$

Therefore, based on our classification model, it can be predicted that given sample is 'female'.

VI. CONCLUSION

In our research work, we have proposed the prediction about playing cricket based on four parameters such as outer vision, climate, dew, and air. The main goal of our research work is to develop an approach for addressing the classification issues which arise in naive bayes classification algorithm. Our approaches were meant to address different types of classifications associated with naïve bayes and gaussian naïve bayes classification algorithms. we have also proposed several novel new parameters to predict the weather conditions for playing cricket. Our work can be extended in various directions. In this paper, we have tried to explore some of the unexplored areas related to classification of supervised learning related to machine learning. But, still, several unexplored points and open issues related to the research in this paper, both theoretical and practical needs further investigation. Now, we briefly outline the following possible extensions to our work.

1. In this work, we have concentrated on classification features like outer vision, climate, dew, and air. But other features like geographical location, past record of pitch can be taken up as a future work.
2. Our methodology can be extended to address the problems of healthcare, automated devices, robotics, educational institutes and other applications etc.

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