Result analysis of Pattern Detection System using an Algorithm of Textual feature investigation and categorization

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***Abstract*—** In this paper, we have a tendency to review some pattern recognition schemes printed in recent years. once giving the overall process steps of pattern recognition, we have a tendency to discuss many ways used for steps of pattern recognition like Principal part Analysis (PCA) in feature extraction, Support Vector Machines (SVM) in classification, and then forth. . Pattern recognition has its roots in artificial intelligence and is a branch of machine learning that focuses on the recognition of patterns and regularities in data. Completely different forms of deserves square measure conferred and their applications on pattern clairvoyance square measure given. The target of this paper is to summarize and compare a number of the ways for pattern recognition, and future analysis problems which require to be resolved and investigated more square measure given alongside the new trends and ideas. Pattern recognition has become a lot of and a lot of standard and vital to U.S. and it induces at-attractive attention coming back from wider areas. The overall process steps of pattern recognition square measure mentioned, beginning with the preprocessing, then the feature extraction, and eventually the classification. many ways were used for every step of pattern recognition like segmentation and noise re-moval in preprocessing, Dennis Gabor wavelets rework for feature extraction, Support Vector Machines (SVM) for classification, and then forth. Some pattern recognition ways square measure conferred and their applications square measure given. the target of this paper is to summarize and compare some ways for pattern recognition, and future analysis problems which require to be resolved and investigated more square measure given alongside the new trends and ideas.

Keywords— PCA, SVM, PH, DLVO, MATLAB

1. Introduction

As of late, there has been an exponential development in the quantity of complex archives what's more, messages that require a more profound comprehension of AI techniques to have the option to precisely group messages in numerous applications. Many AI approaches have accomplished outperforming brings about normal language handling. The accomplishment of these learning calculations depends on their ability to comprehend complex models and non-direct connections inside information. This review covers extraordinary content component extractions, dimensionality decrease strategies, and existing calculations and systems, and assessments techniques. At long last, the confinements of every strategy and their application in genuine world. Statistical sample recognition is worried with the problem of designing machines which could classify complex patterns. Although statistical pattern reputation is usually considered as a department of Artificial Intelligence, such problems frequently stand up in the social and behavioral sciences within the path of detecting complicated structural relationships in large facts sets. Statistical Pattern popularity problems additionally stand up inside the route of modeling complex social, behavioral, and neural structures. Most statistical pattern recognition systems consist of 3 most important additives. The first element is a feature selection and extraction level where vital informational features about the statistics are identified for type purposes. The 2d factor is a probabilistic information illustration for representing the expected chance of unique features and the associated losses for making scenario-precise choices. Pattern reputation is the most primary description of what's finished inside the system of facts mining. Usually, those styles are stored in dependent databases and organized into statistics, which are composed of rows and columns of statistics.

Different colorimetric patterns are shaped on chemically sensitive substrates such as universal indicator strips when compounds or substances of different pH values are dropped on them i.e. along with different color they exhibit on substrates, also they tend to expand or diffuse at different rates forming different patterns.

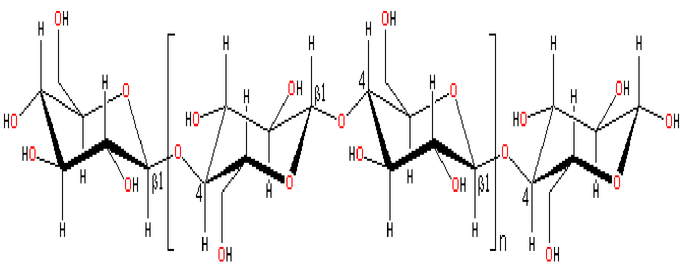


Figure1.1: Structure of Cellulose

The overall pattern formed on substrate of varied substances diffrers in context to the color they imprint along with the movement they show on universal indicator strip available.

The expansion pattern formed due to different bondings of different pH value solutions with pH paper and the color pattern was studied.

1.1 Correlation of pH and Concentration of Hydrogen Ions

Concentration of hydrogen ions is closely related to pH value. The properties of acid and bases are determined by the pH value which depends on the concentration of hydrogen Ions concentration in the solution. It is difficult to understand pH value of a solution without getting to know about concentration of elements [7]. PH measures negative log of hydrogen ions concentration. Logarithmic scale is used as it retains valuable information which is represented by Ph scale. The connection between pH and concentration of hydrogen Ions can be understood such that they are linearly connected i.e. pH change by factor of one when concentration of hydrogen ions changes by factor ten as given in [11].

pH = $-\log[H^+]$ $[H^+]$ here represents the concentration of hydrogen ions. 1 mol/L depicts a solution in which 1 mole of hydrogen ions is present in 1 liter. A value of 1 μmol/L specifies a solution in which 1 millionth of a mole of hydrogen ions is present in 1 liter. The following table shows how pH value affects the hydrogen Ion concentration [11].

pH	$[H^+]$ (μmol/L)	pH	$[H^+]$ (μmol/L)	pH	$[H^+]$ (μmol/L)	pH	$[H^+]$ (μmol/L)
3.0	1000	4.0	100	5.0	10.0	6.0	1.00
3.1	794	4.1	79	5.1	7.9	6.1	0.79
3.2	631	4.2	63	5.2	6.3	6.2	0.63
3.3	501	4.3	50	5.3	5.0	6.3	0.50
3.4	398	4.4	40	5.4	4.0	6.4	0.40
3.5	316	4.5	32	5.5	3.2	6.5	0.32
3.6	251	4.6	25	5.6	2.5	6.6	0.25
3.7	200	4.7	20	5.7	2.0	6.7	0.20
3.8	158	4.8	16	5.8	1.6	6.8	0.16
3.9	126	4.9	13	5.9	1.3	6.9	0.13
4.0	100	5.0	10	6.0	1.0	7.0	0.10

Figure1.2: Correlation between pH and H^+ Concentration

1.2 Importance of pH Value

The pH value in general is referred to as "power of hydrogen". The pH value of solution provides clarity about the substance being acidic or basic. The hydrogen ion concentration and pH value are correlated to each other to a large extend. For determination of concentration of hydrogen ions or pH value different colorimetric analysis method is being used currently. Colorimetric analysis refers to a method of determination of the concentration of a chemical element compound in a solution with the assistance of a color reagent. Any substance which is soluble in particular solvent can be categorized on the bases of H^+ ions. It is either acidic or basic in nature or lies between the two contrasts.

1.3 Methods of pH Determination

Different methods to know the value of pH exist today; most widely used method being pH meter. The pH meter determines a precise pH with the aid of a suitable electrode submerged in the unknown solution [9]. A direct and immediate reading is registered on the pH meter scale.

Figure1.3: Ph Meter

Simplest being use is litmus paper which has its availability in two colors blue and red. Blue litmus paper turns red when exposed to acidic situation and red litmus paper turns blue under basic environment.

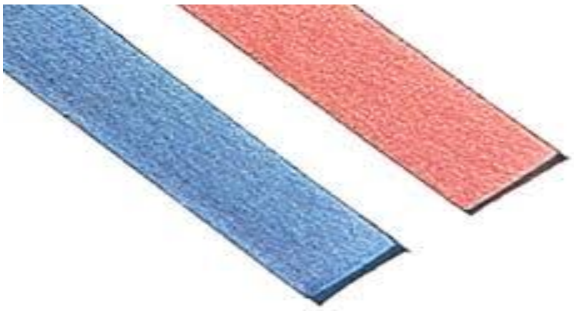


Figure1.4: Litmus Paper Strips

The following table given below shows how litmus paper reacts to varied solutions accordingly [10].

Table 1.1 Description of Litmus Paper Reaction to varied Solutions

	Red litmus	**Blue litmus**
Acidic solution	Stays red	Turns red
Neutral solution	Stays red	Stays blue
Alkaline solution	Turns blue	Stays blue

2. Literature Review

Flow in a porous medium can be depicted by flow equation where the frictional flow resistance of the porous structure is conventionally given by Darcy -type interaction terms. Darcy's law for an incompressible single-phase flow in a porous substance with insignificant inertial and gravitational effects is given:-

- Δp is the fluid pressure difference
- μ the dynamic viscosity of the fluid
- h the thickness of the material
- k is the permeability coefficient of the substance.
- In eq. (3) the permeability coefficient k includes every information in regards the complicated microscopic porous structure of the substance.

2.1 DLVO Theory in Particle Transport

DLVO theory predicts the particle movement by calculating the net potential of V_a(generally attractive) and V_r(repulsive if the surface charge of the particles and porous media are homogeneous) between particles and the porous surface.

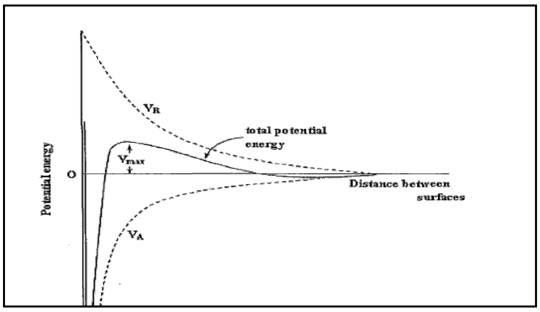


Figure 2.1: Scheme of DLVO

At first attraction of particles towards porous medium is observed due to Vander walls forces, as a result they tend to move towards porous medium surface but once distance between particles and porous medium decreases to specific range V_r become much significant and generate energy barrier to avert advance approach of particles. If particles overcome energy barrier, to overcome this V_a would dominate again and cause the particle deposing on porous media.

2.2 Factors Affecting Diffusion

There are numerous factors that affect the rate at which particles diffuse on a substrate. Some of them are:

2.2.1 Inner Structure

- Cohesion- It is inversely proportional to rate of diffusion. Better is the bond between molecules of the substance less is their tendency to contribute to diffusion.
- Adhesion- It is directly proportional to rate of diffusion. Superior is interaction between the substrate and liquid more will be its tendency to diffuse.

2.2.2 Ambient Conditions

- Temperature- It is directly proportional to rate of diffusion [22].
- Pressure- It is directly proportional to rate of diffusion. As accordance with the Henry's Law.
- Humidity- More humidity means more water vapor in the air.

2.3 Generative Models in Machine Learning

In statistics and probability, a generative model is a sculpt used for arbitrarily generating observable data values, normally when provided some concealed parameters, It then specifies a joint probability distribution over observation and label series.

Generative models are employed in machine learning for either modeling data directly or as an transitional pace to form a conditional probability density function. Bayes rule can be used to form a conditional distribution using a generative model to simulate (i.e. generate) values of any variable in the model [4]. Examples of generative models include:

- Gaussian mixture model and other types of mixture model
- Hidden Markov model
- Naive Bayes
- Discriminant Analysis
  - Linear Discriminant Analysis
  - Quadratic Discriminant Analysis

- **Gaussian Mixture model**

  Gaussian Mixture Model (GMM) is a parametric probability density function represented as a weighted sum of Gaussian component densities. GMM parameters are anticipated from training data using the iterative Expectation-Maximization (EM) algorithm or Maximum APosteriori (MAP) estimation from a well-trained previous model.

2.4 Related Work

Loh, B. Y. et al.(2011),.[5] have proposed a stout classification algorithm that can relate color science and image processing techniques which is developed to automatically identify the pH level on a test strip.

Yetisen, Ali et al. (2011). [1] Proposed a smart phone application algorithm with inter-phone repeatability. The app transformed the smart phone into a reader to quantify commercial colorimetric urine tests with high accuracy and reproducibility in measuring pH, protein, and glucose.

Zolqernine Othman et al. (2012), [19] author discussed, that Canny method is better at producing good edge with the smooth continuous pixels and thin edge. Both of the methods i.e. Sobel and Canny are quite sensitive to the noise pixels.

Som, H. M. et al. (2012),[2] has discussed and showed that Otsu methods does works well with clearly scanned images i.e. images with proper illumination and no shadow, but it performs unsatisfactorily for those not so good quality images that have low contrast illumination issues.

Jain, A et al. (2012), [29] discussed that though, Gradient based edge detectors like Prewitt and Sobel are relatively simple and quite easy to implement, but are quite sensitive to noise.

3. Problem Formulation

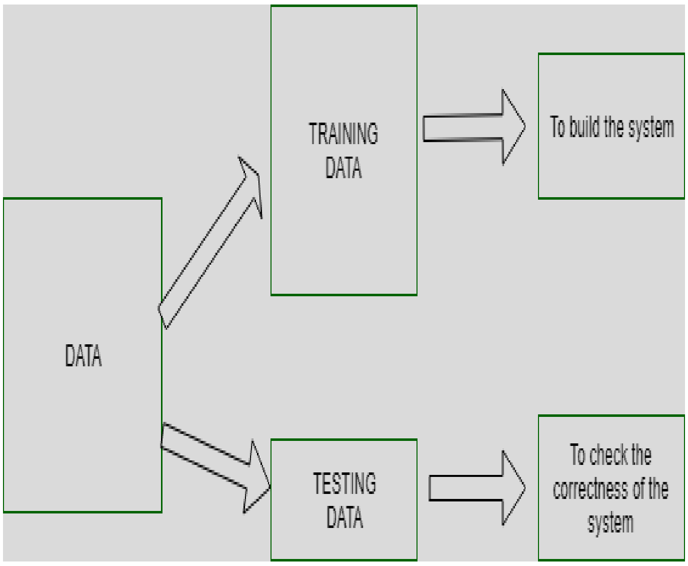
The basic process of chaos optimization algorithm generally includes two major steps.

- Firstly, define a chaotic sequences generator based on the logistic map. Generate a sequence of chaotic points and map it to a sequence of design points in the original design space. COA has a very sensitive dependence upon its initial condition and parameter. Chaotic sequences have been adopted instead of random sequences and somewhat good results have been shown in many applications. Then, calculate the objective function based on the generated design points, and choose the point with the minimum objective function as the current optimum.
- Secondly, the current optimum is assumed to be close to the global optimum after certain iterations, and it is viewed as the consult point with a little chaotic perturbation and explores the descent direction along axis directions in order.

- Repeat the above two steps until some specified convergence criterion is satisfied, then the global optimum is obtained. However, further numerical simulation showed that the method is effective only in small design space.

3.1 Proposed Model

Testing data is used to test the system. It is the set of data which is used to verify whether the system is producing the correct output after being trained or not. Generally, 20% of a of the dataset is used for testing. Testing data is used to measure the accuracy of the system. Example: a system which identifies which category a particular flower belongs to, is able to identify seven category of flowers correctly out of ten and rest others wrong, then the accuracy is 70 %



A pattern is a physical object or an abstract notion. While talking about the classes of animals, a description of an animal would be a pattern. While talking about various types of balls, then a description of a ball is a pattern. In the case balls considered as pattern, the classes could be football, cricket ball, table tennis ball etc. Given a new pattern, the class of the pattern is to be determined. The choice of attributes and representation of patterns is a very important step in pattern classification. A good representation is one which makes use of discriminating attributes and also reduces the computational burden in pattern classification. An obvious representation of a pattern will be a **vector**.

3.2 Objectives

The main objectives for the upcoming research work in the field are as follows:

1. To develop a model which incorporates the ability to classify pH class of a substance dribbled on a substrate understanding the colorimetric patterns formed by substance on chemically sensitive substrate.
2. To implement generative algorithms to solve the problem of classification of colorimetric patterns on chemically sensitive substrates; such that better and enhanced classification is achieved using image processing and machine learning methods

3.3 Software Requirements:

Tool: MATLAB 2016

The tool required for computing and analyzing the whole system is MATLAB which is a versatile tool for technical simulation and computing. MATLAB has powerful graphic tools and can create fastidious pictures in both 2D and 3D. It is also a programming language, and is one of the trouble-free programming languages for writing arithmetical programs..

3.4 Results and Comparison

Results achieved from both the models are evaluated and compared.

Step 1: Firstly, the image is read and converted into a grayscale image to increase the visualization and reduce the complexity of the image.

Step2: We then threshold the image using specific edge detection.

Step 3: Image is dilated to get the lines of high contrast

Step 4: Border of image is cleared, to get clearer image.

Step 5: Then detected object is outlined using bounding box.

3.5.1 Methodology of Cluster Based: K Means

Step 1: Firstly the image to be processed is read.

Step2: It is converted L*a*b Color space using K mean Clustering, The L*a*b* space consists of a luminosity layer

'L*', chromaticity-layer 'a*' indicating where the color falls along the red-green axis, and chromaticity-layer 'b*' indicating where the color falls along the blue-yellow axis.

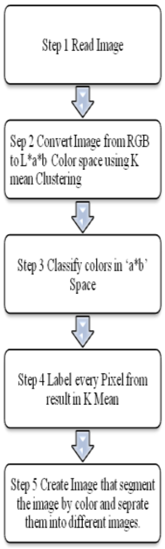


Figure 3.4: K-Means Methodology

Step 3: Since, color information exists in the 'a*b*' space, your objects are pixels with 'a*' and 'b*' values.

Step 4: Now we can measure the difference between two colors using the Euclidean distance metric. For every object in your input, k means returns an index corresponding to a cluster [13].

Step 5: Lastly using pixel labels, objects are separated.

3.5.2 Methodology for Threshold Based Techniques

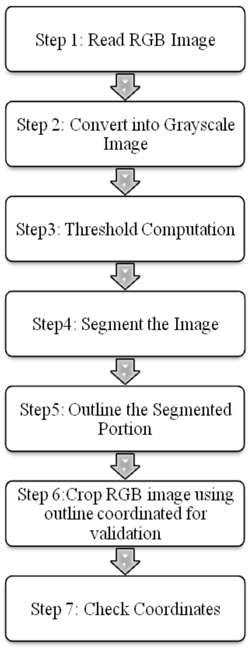


Figure 3.5: Methodology for threshold Based Techniques

Step1: Image to be processed is read.

Step 2: It is then converted to grayscale image.

Step 3: Threshold is calculated using specific technique.

Step 4: Image is segmented using the specified threshold.

Step 5: The object detected using technique is outlined using bounding box.

Step 5: Image is cropped to the coordinates of bounding box.

Step 6: Coordinates are checked and compared to the ones needed.

3.5.3 Methodology for Edge Filter Technique

Step 1: Laplacian is calculated for each pixel

Step2: Histogram of pixels with large laplacians is created.

Step 3: Using this new histogram a threshold can be detected using mean gray level.

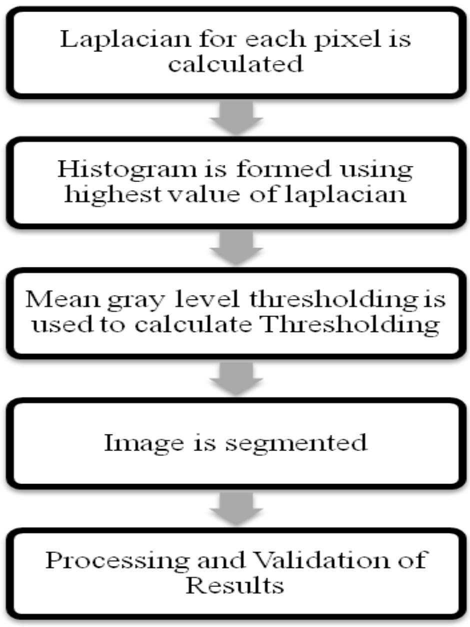


Figure 3.6: Methodology for Edge Filter Based Method

Step 4: Image is segmented using the achieved threshold [14].

Step 5: Image is processed to get required segmented portion and results are validated.

4. Data Analysis Result: Ordinate Expansion Trend

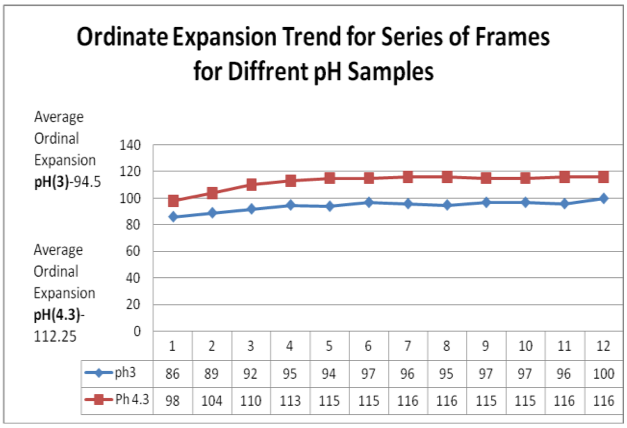


Figure (a): Ordinal Expansion Trends by different pH Samples

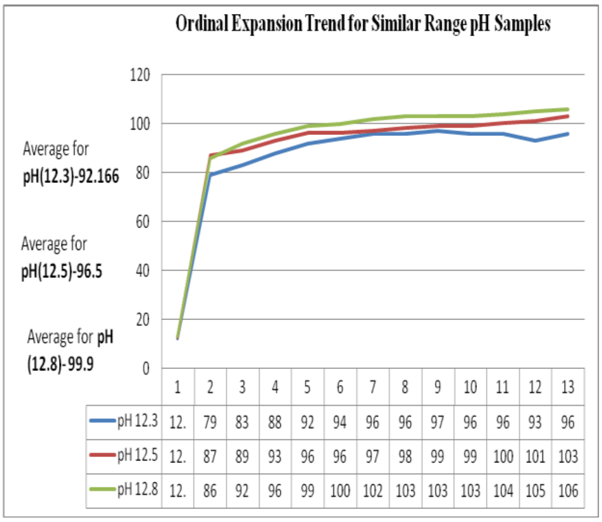


Figure (b) - Ordinal Expansion Trends by different pH Samples

From the above graphs depicting the change in height of the pH sample which is based on the ordinal expansion; we can say that samples with varied pH values show dissimilar expansion patterns when considered over same time frame and the average distance to which they expand is noticeably different. This parameter is of much use and hence, can be used as a distinguishing criterion for classification based problem. Secondly, substance which does not have much pH value difference or lie in same range also show different expansion patterns in context to the average distance they move in ordinate axis is distinguishable.

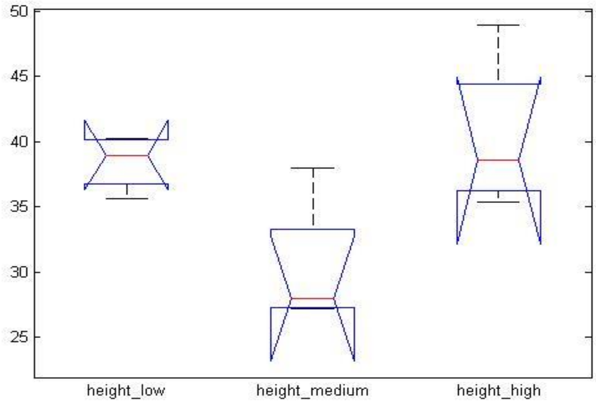


Figure (a) - Ordinal Trends shown by different pH Classes

From the above graph we can clearly observe that pH samples divided into different pH Classes show different trends in consideration of ordinal expansion.

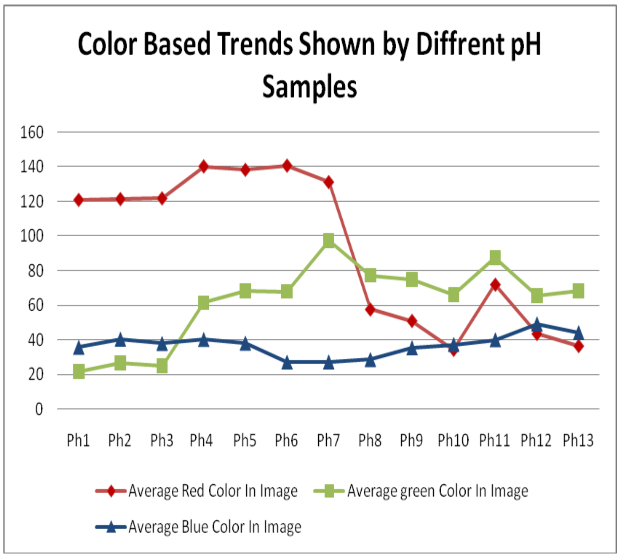


Figure (b) – Color Based Trends shown by different pH Classes

Different pH samples also tend to show different color based trends on universal pH strip as expected; the data extracted i.e. the red component, blue component and green component and the average values of components over each sample which are quite distinguishable when captured through mobile phone. Considering these color trends as attributes classification model can be created, for prediction of pH sample class.

4.1 Data Division and Evaluation

Data was divided into training data and test data according to the validation applied. The validation factor was chosen in accordance to divide the data such that 70% data was taken as training data and 30% data approximately as test data in k folds. The validation procedure allows data to be chosen randomly k number of times. Where 'k' is number of folds and division is also in according to value of k. This allows training data to be shuffled k times thus allowing a better performance evaluation.

Figure Data Division for Classification

- **Recall**

  The recall refers to evaluate the classifier output quality. The recall (R) is defined as the number of true positives (Tp) over the number of true positives plus number of false negatives (Fn) i.e.

$$R = \frac{Tp}{Tp + Fn}$$

Table Data samples of Various Classes

Classes	**Class Labels**	**No of Samples**
Class Low	**0**	**54**
Class Medium	**1**	**25**
Class High	**2**	**41**

4.2 Ordinal expansion and Red Color Coordinate

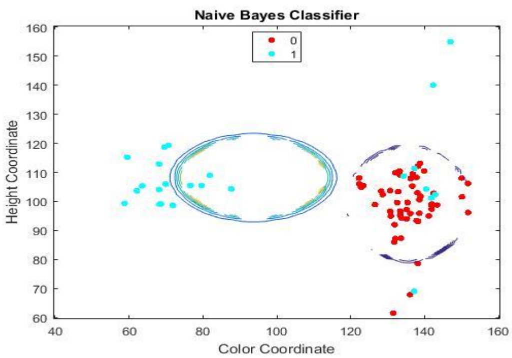


Figure Classification by Naïve Bayes for between Ordinate Expansion and Red Color Coordinate for Classes (Low (0) and Medium (1))

Table - Confusion Matrix for Ordinate Expansion and Red Color Coordinate for Classes (01)

	Predicted Low	**Predicted High**
Actual low	**15**	**1**
Actual High	**2**	**5**

Table: Performance Measures (01)-Ordinate and Blue Coordinate

Accuracy	**86. 95%**
Precision	**88.23%**
Recall	**93%**

4.3 Ordinal expansion and Blue Color Coordinate

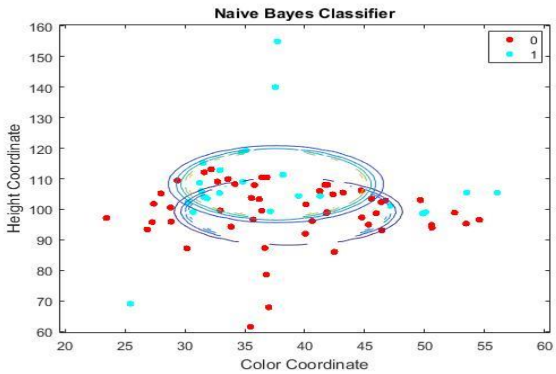


Figure Classification by Naïve Bayes for between Ordinate Expansion and Blue Color Coordinate for Classes (Low (0) and Medium (1))

Table Confusion Matrix (01)-Ordinate Diffusion and Blue Color Coordinate

	Predicted low	**Predicted High**
Actual Low	**14**	**2**
Actual High	**6**	**1**

Table: Performance Measures (01)-Ordinate and Blue Coordinate

Accuracy	**65.23%**
Precision	**70%**
Recall	**87.50%**

4.4 Ordinal expansion and Green Color Coordinate

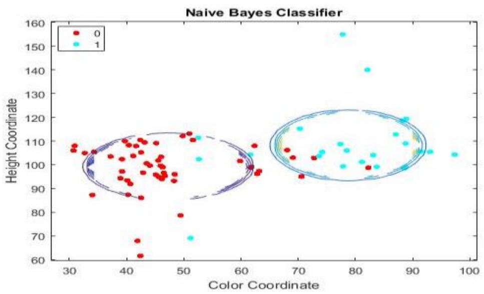


Figure Classification by Naïve Bayes for between Ordinate Expansion and Green Color Coordinate for Classes (Low (0) and Medium (1))

Table Confusion Matrix (01)-Ordinate Diffusion and Green Color Coordinate

Accuracy	**68.42%**
Precesion	**55.55%**
Recall	**71.42%**

	Predicted low	**Predicted High**
Actual low	**15**	**1**
Actual High	**3**	**4**

Accuracy	**82.60%**
Precesion	**83.33%**
Recall	**93.75%**

Table: Performance Measures (01)-Ordinate and Green Coordinate

4.5 Ordinal expansion and Red Color Coordinate for Class Medium and High

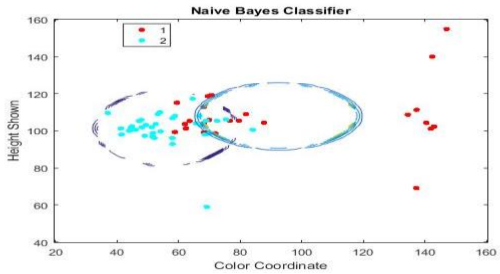


Figure Classification by Naïve Bayes for between Ordinate Expansion and Red Color Coordinate for Classes (Medium (1) and High (2))

Table Confusion Matrix (12)-Ordinate Diffusion and Red Color Coordinate

	Predicted Medium	**Predicted High**
Actual Medium	**5**	**2**
Actual High	**4**	**8**

Table Performance Measures (12)-Ordinate and Red Coordinate

4.6 Ordinal expansion and Blue Color Coordinate for Class Medium and High

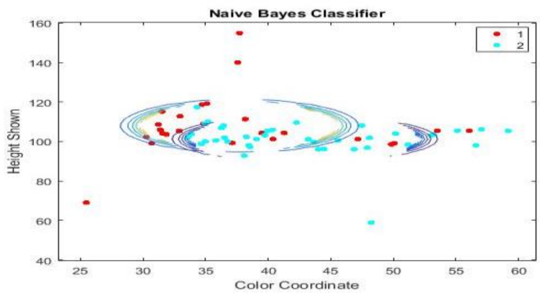


Figure Classification by Naïve Bayes for between Ordinate Expansion and Blue Color Coordinate for Classes (Medium (1) and High (2))

Table Confusion Matrix (12)-Ordinate Diffusion and Blue Color Coordinate

	Predicted Medium	**Predicted High**
Actual	**4**	**3**

Medium		
Actual High	**0**	**12**

Table: Performance Measures (12)-Ordinate and Blue

Coordinate

Accuracy	**84.21%**
Precision	**100%**
Recall	**57.14%**
Accuracy	**91.11%**
Precision	**88.52%**
Recall	**100%**

Actual High	**1**	**40**

4.7 Ordinal Expansion and Green Color Coordinate for Class High and Class Low

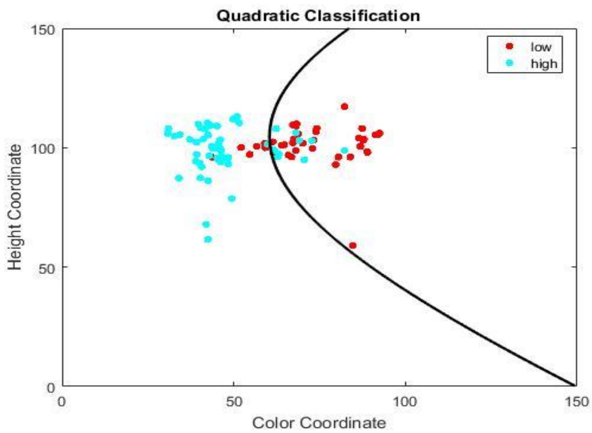


Figure Classification by Quadratic Discriminant Analysis for between Ordinate Expansion and Green Color Coordinate for Classes (Low (0) and High (2))

Table: Confusion Matrix (02)-Ordinate Diffusion and Green Color Coordinate: QDA

	Predicted low	Predicted High
Actual low	**33**	**8**
Actual High	**9**	**45**

Table Performance Measures (02)-Ordinate and Green

4.8 Comparison of Generative Models Based on Performance Evaluation Parameters

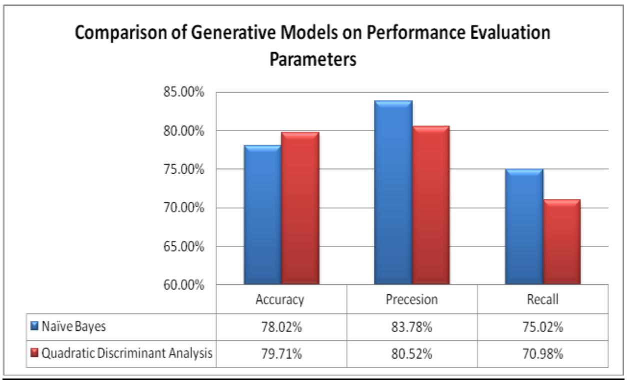


Figure- Overall Comparison of Models on basis of Ordinal Expansion and Color Patterns

From the above comparison, we see that both the generative models perform quite well with Quadratic Discriminant Analysis performing much better in context to accuracy. While, Naïve Bayes outperforms on the performance matrices of Precision and Recall.

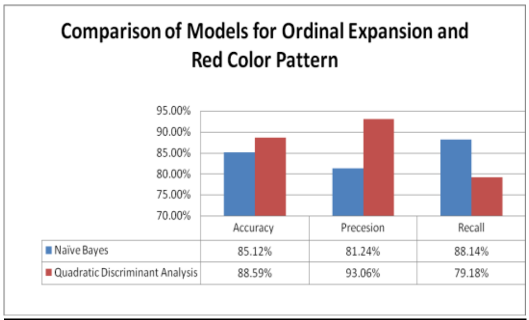


Figure- Performance Evaluation and Comparison of Models for Ordinal Expansion and Red Color Pattern

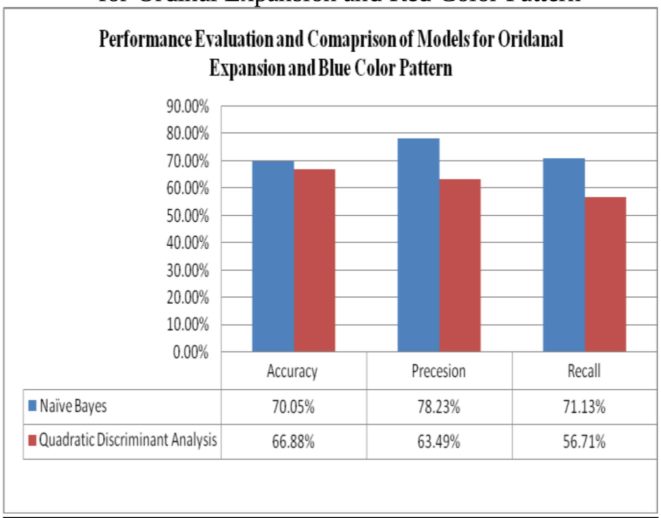


Figure- Performance Evaluation and Comparison of Models for Ordinal Expansion and Blue Color Pattern

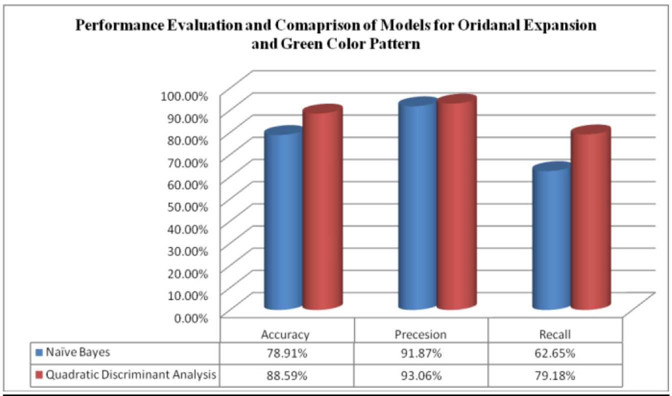


Figure- Performance Evaluation and Comparison of Models for Ordinal Expansion and Green Color Pattern

5. Conclusion and Future Scope

Studying the results obtained from analysis of colorimetric patterns on sensitive substrates such as universal pH strip; it has been found that the existing correlation between pH of substance and expansion trend depicted by theories such as DLVO theory of particle expansion and surface diffusion law by Adolf Fick's can be used as base to classify substances of different pH values into classes. Substances with varied pH values have entirely different concentration of hydrogen Ions which tend to form assorted bonding with the cellulose present in the pH paper which have a affect on the expansion pattern a particular substance exhibit. Substances with varied pH value also exhibit entirely different color based patterns which can serve as a strong base of differentiation of samples from each other. Both the patterns when combined can form a strong model for differentiation and classification of samples using machine learning based approaches. For the classification part generative models are a great advent in field of machine learning. Both the generative models are seen to perform equally well. Considering Accuracy as parameter Quadratic Discriminant Analysis outperforms Naïve Bayes in considering all parameters as a whole and eve if ordinal expansion is considered with respect to red or blue color. Though Naïve Baye's provide a better accuracy in consideration for the result of blue color and Ordinal expansion the margin of surpass is quite little i.e. just 3.17%. A entirely different scenario is seen if recall is considered as a parameter where Naïve Bayes outperforms in overall parameter consideration as well as if we compare it on bases of ordinal expansion and red as well as blue color coordinate. In case of green color and ordinal expansion trend Quadratic Discriminant Analysis does perform better but not with a noticeable margin. Considering Precision it is evidently witnessed that Naïve Baye's performs quite well off by outperforming

6. Future Scope

The data extracted could be analyzed using much more advancement. This will allow features to be extracted to much more perfection which will yield enhanced data and hence a better classification. More generative classifiers can be implemented and worked upon to distinguish and get better results. Number of classes on which current classification is to be performed; could be increased to an extent, which would allow a very close range of pH value to be predicted.

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