

Parametric Extraction of the Road Conditions Spatial Data and Detection of Defeats using Pragmatic Clustering Method

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Abstract: Growth in the population and road transportation for any region can create a higher demand for better road conditions and the less safe road conditions can be a great bottleneck for the growth of the nation. Hence most of the progressive nations like India, builds better infrastructure for the road transportations. Nevertheless, the higher populations in countries like India, demand greater maintenance of the roads and for a gigantic demographic, the maintenance work can be very tedious. Also, the damage in the road surfaces can also lead to the increasing rate of the accidents. Henceforth, the demand of the road maintenance is always increasing. Nevertheless, the existing road maintenance authorities deploy a manual process for identification of the repair needs, which is naturally highly time consuming. Thus, this work identifies the demand for automation of the road condition monitoring system and identifies the defects based on three classes as cracks, patch works and potholes on the road surface. The work deploys a novel model for parametric extraction, in order to segregate the defect types. The segregation of the defect types can be highly challenging due to the nature of the data, which clearly hints to solve the problem using unsupervised methods. Thus, this work also deploys a pragmatic clustering method using a decisive factor, which is again generated from the extracted features of parameters. The work demonstrates nearly 96% accuracy on the benchmarked dataset with sophistication on the complexity of the model.

Keywords: Road condition identification, Pragmatic Clustering, Parametric Analysis, intensity Variation, Coordinate Mapping, Segmentation.

I. INTRODUCTION

The road conditions in any country or region are one of the crucial factors for the transportation of people or goods and directly influence the economy. The report presented by European commission et al. [1] on 2018 have significantly demonstrated that small deviation of the road condition can lead to fatal accidents. Moreover, the defected road surfaces can also cause problem to the vehicles, especially to the components like break, suspension and drive wheels. Hence the growing countries like India puts some great efforts to maintain the road surfaces cleaned from defects. Yet another report from the C. N. do Transports[2] also reported that the deformation in the road conditions can lead to increase in the safety hazards from 25% to 50% in one single year 2010.

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Thus, the regular monitoring of the road conditions must increase.

Henceforth, realizing the increasing demand and increasing safety concerns, many of the researches have attempted to detect the road surface defects by various means. The manual process of detecting the road conditions is highly difficult and relies on the human efforts. Henceforth, the researchers are aiming to automate the detection process and the work by A. Fox[3] is the first of its kind to automate the process. This work deploys the detection of the road defects using vehicle mounted sensors and the further process the data in order to detect the defects. The outcome from this work have significantly changed the way this research problem was viewed in the past and number of researchers have shifted their attention towards the information extraction-based solution to this problem. Nevertheless, the identification of the defects is not sufficient in order to proceed for the proper repair works. Thus, classification of the road condition defects such as cracks, patchworks or potholes must be detected.

Henceforth, this work demonstrates a novel outcome-based model for extraction of the parameter and further builds pragmatic clustering solution to identify the type and severity of the defects as well.

The rest of the work is elaborated as in section – II, the traditional clustering method is elaborated and the subsequent problems are identified, in section – III, parallel research outcomes are analysed with the gaps in the results, in section -IV, the problem is identified and formulated, in section – V, the proposed solution is formulated using mathematical modelling, in section -VI, the proposed algorithm is discussed, the results are furnished in section – VII, the comparative analyses is carried out in section – VIII, and the work presents the final conclusion in the section – IX.

II. TRADITIONAL CLUSTERING METHOD

In this section of the work, the traditional clustering method as fundamental is discussed. The fundamental understanding of the existing traditional system is important as this helps in the realizing the advancements made to the fundamental principle by the parallel research works.

Firstly, assuming that, $D[]$ is the initial dataset and it is a collection of multiple attributes forming the data domain, where each and every attribute can be denoted as A_x . Thus, for a total of n number of attributes, this can be formulated as



$$D[] \Rightarrow \sum_{i=1}^n A_i \quad (\text{Eq.1})$$

Further, each attribute A_x must be analysed for the data domain,

$R(A_x)$, and for a total of r number of total observations, this relation can be noted as,

$$A_x \Rightarrow \sum_{j=1}^r \mathfrak{R}(A_x)[j] \quad (\text{Eq.2})$$

Further, one of the attributes must be identified as the class attribute, A_c , in the dataset and the other attributes must be mapped against the class attributes in order to form the clusters.

Assuming that, the distribution of the data for any attributes A_x , can be observed to have three similarity distribution, then the data domain for the attributes can be separated in three segments as,

$$C_p = \int_{j=1}^r |\mathfrak{R}(A_x)[j] \rightarrow \lambda| \quad (\text{Eq.3})$$

Here, λ denotes the central tendency for the quartile.

Henceforth, for each attributes the formation of the clusters must be realized, and any sample cluster can be visualized as following [Fig-1].

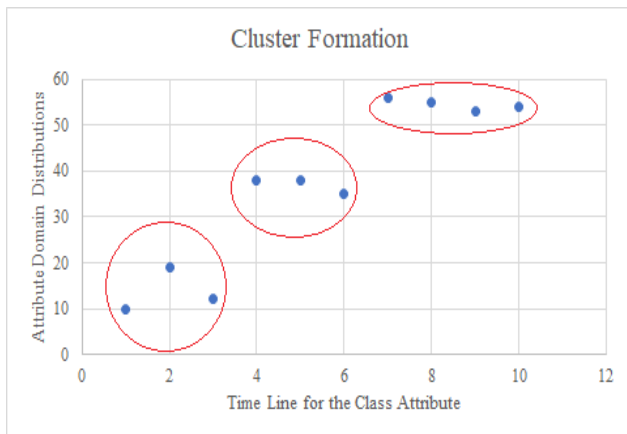


Fig 1: Sample Cluster Formulations

This fundamental knowledge will help in realizing the advancements studied in the next section of the work for the parallel research outcomes.

III. PARALLEL RESEARCH OUTCOMES

After the realization of the fundamental principle of the process, in the section of the work, the parallel research outcomes are analysed in detail.

The work outcome by T. Kim [4] have significantly demonstrated and comparative studies from various other research attempts. From this work, the conclusive statement can be generated as, the gaps in the research is existing and further elaborations of the solution is a must. Also, the parallel research works majority focuses on the two-dimensional dataset, whereas the demand from the trends are towards the spatial data. The similar problem solution was proposed using machine learning approaches by S.Karabachos . [5] which is again a land mark for this domain of the research as the reduction is very high.

In the recent times, the popularity of the automated vehicles are also increasing and the demand for avoidance of the defected surface is gaining. thus, the extraction of the parametric observation for the road surface defects is one of the prime tasks for this domain of research. The work by H. Bello – Salau [6] have showcased the solution specific extraction of the parameter are possible and further the solution accuracy can be improved to a greater extend. The applicability of the wavelet-based solutions can directly be applied for the purposed [7] as demonstrated by F. M. Bayer [8].

In the other hand, many of the research attempts such as the work by K. Azhar [9] focuses on the traditional image processing mechanisms and further extraction of the parameter some of the other research attempts like the work by P. Wang [10] have applied segmentation methods for identification of the defect objects on the image.

Few of the research attempts have demonstrated the application of neural neural networks such as the work by H. Maeda [11] and achieved a higher accuracy. However, these works had to compromise on the time complexity for the initial data processing tasks.

Henceforth, with the detailed understanding of the parallel research outcomes, this work proposes for formulation of the problem in the next section of the work.

IV. IDENTIFICATION OF THE PROBLEM

After the detailed understanding of the parallel research outcomes, in this section of the work, the research problem is identified. The fundamental problems are identified based on the parallel research outcomes are two as for detection of the defects on the road surface are critical and sufficient parameters must be identified and, in the situations, where the unavailability of the class attributes ca lead to unsupervised learning methods, the collaborative formulation must be carried out to collaborate all the attributes.

A. Insufficient Extraction of the parameter

Firstly, assuming that the spatial data is denoted by $SP[]$ and each and every component of the dataset must be defined as D_x . Thus, for a total of n number of attributes, this relation can be formulated as,

$$SP[] = \sum_{i=1}^n D_i \quad (\text{Eq.4})$$

Further, the data components must be equipped with the parameters such as segmentation information, SI, distance between the segmentation, DS, Depth, D, Width, W, and finally the area A. Assuming that, every image, I, can be represented using the collection of pixel vector, $p[][]$, then for a n, m number of pixels, the relation can be formulated as

$$I = \sum_{i,j}^{n,m} P[i][j] \quad (\text{Eq.5})$$

However, in order to extract the SI and A, the boundary information of the image must be extracted using the coordinate information, $corr[][]$, as,

$$Corr[][] \leftarrow P[][] \quad (Eq.6)$$

And

$$A \leftarrow \frac{\prod_{Count} Corr[][]}{\left[\prod_{Count} Corr[][] - P[][] \right]} \quad (Eq.7)$$

Hence, the coordinate information is a must to have for the image information extraction.

Furthermore, in order to calculate the DS and W, the maxima and minima information, max & min, from the coordinate information is a must to contain, as,

$$\max \leftarrow \frac{\prod_{Length_max} Corr[][]}{Corr[][]} \quad (Eq.8)$$

And

$$\min \leftarrow \frac{\prod_{Length_min} Corr[][]}{Corr[][]} \quad (Eq.9)$$

Thus, the maxima and minima information are must to have for the image information extraction.

Finally, in order to extract the D, the intensity variation, IV, is a must to obtain as,

$$D \leftarrow \frac{IV[]}{\Delta t} \quad (Eq.10)$$

Based on the parallel research outcomes, it is been observed that these expected parameters are not been considered during the parametric extraction of the road condition.

Thus, this work elaborates on the extraction of the demonstrated and identified parameters.

B. Unavailability of the determining factors

Secondly, during the clustering process, the validity of the clusters is highly difficult as the parameters are different in nature and mostly the parameters multivariate.

Multivariate examination can be entangled by the craving to incorporate material science-based investigation to compute the impacts of factors for a various levelled “arrangement of frameworks”. Regularly, examines that desire to utilize multivariate examination are slowed down by the dimensionality of the issue. These worries are regularly facilitated using surrogate models, profoundly precise approximations of the material science-based code.

Henceforth, based on the parallel research outcomes, it is been observed that the determining factor based on deep calculation or pragmatic calculation is highly recommended.

Thus, this work demonstrates the pragmatic cluster formation in the next section.

V. PROPOSED SOLUTION- MATHEMATICAL MODEL

After the detailed analysis of the parallel research outcomes and preceded by identification of the problem, in this section of the work the mathematical model is presented.

The work demonstrates the mathematical model for five different components of the solutions here.

LEMMA -I: Extraction of the coordinate values from the pixel information can determine the maximal and minimal distance between the objects in the road condition information.

PROOF: Assuming that spatial data set is denoted as SPD and each and every SPD is collection of the image, I_x and other data information $D[]$. Thus, this can be formulated as,

$$SPD = \langle I, D[] \rangle \quad (Eq.11)$$

Further, the image component Can be represented as collection of pixel information, $P[][]$, for n rows and m columns. This can be formulated as,

$$I_x = \sum_{i,j}^{n,m} P[i][j] \quad (Eq.12)$$

Assuming that, the image pixels are not converted to the gray scale variation, the image must be converted to the gray variation as

$$P_G[][] = \prod_{(r,g,v) \rightarrow gray} P[][] \quad (Eq.13)$$

Henceforth, the image pixels sets are ready to converted into the coordinate mapping into coordinate vector, $Corr[][]$ as,

$$Corr[][] = \text{Iff } P_G[i][j] \neq \phi \quad (Eq.14)$$

Where, ϕ denotes the background pixels or the pixel from the background regions.

Henceforth, for the image objects, I_1 and I_2 are converted into two different coordinate vectors as $Corr_1[]$ and $Corr_2[]$, as

$$Corr_1[][] \leftarrow I_1 \quad (Eq.15)$$

And,



$$Corr_2[][] \leftarrow I_2 \quad (\text{Eq.16})$$

Further, the locations maxima, max1 and max2 and the location minima, min₁ and min₂ can be formulated as

$$\max_1 = \prod_{\max} Corr_1[][] \quad (\text{Eq.17})$$

And

$$\max_2 = \prod_{\max} Corr_2[][] \quad (\text{Eq.18})$$

With,

$$\min_1 = \prod_{\min} Corr_1[][] \quad (\text{Eq.19})$$

And,

$$\min_2 = \prod_{\min} Corr_2[][] \quad (\text{Eq.20})$$

Further, the actual minima, α , and actual maxima, β from the coordinate vector can be extracted using the mapping method [Fig-2] as,

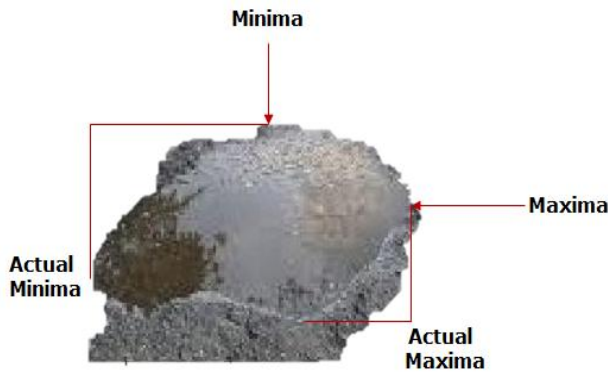


Fig. 1 Minima and Maxima Mapping from Coordinate Vector

$$\alpha_1 = \prod_{\min_1(0,m) \cap \max_1(0,m)} Corr_1[][] \quad (\text{Eq.21})$$

And,

$$\alpha_2 = \prod_{\min_2(0,m) \cap \max_2(0,m)} Corr_2[][] \quad (\text{Eq.22})$$

With

$$\beta_1 = \prod_{\min_1(n,0) \cap \max_1(n,0)} Corr_1[][] \quad (\text{Eq.23})$$

And

$$\beta_2 = \prod_{\min_2(n,0) \cap \max_2(n,0)} Corr_2[][] \quad (\text{Eq.24})$$

Thus, the distance vector for minimal distance, DS_{\min} and distance vector for maximum distance DS_{\max} can be formulated as

$$DS_{\min} = |\alpha_1 - \alpha_2| \quad (\text{Eq.25})$$

And

$$DS_{\max} = |\beta_1 - \beta_2| \quad (\text{Eq.26})$$

Thus, the extraction of the minimum and maximum distance is completed the results obtained from this algorithm is elaborated in the further section of this work.

LEMMA-2:Extraction of the intensity variation can produce the depth of the defects using the centroid estimation in the road condition information.

PROOF:Assuming that spatial data set is denoted as SPD and each and every SPD is collection of the image, I_x and other data information $D[]$. Thus, this can be formulated as,

$$SPD = \langle I, D[] \rangle \quad (\text{Eq.27})$$

Further, the image component can be represented as collection of pixel information, $P[][]$, for n rows and m columns. This can be formulated as,

$$I_x = \sum_{i,j}^{n,m} P[i][j] \quad (\text{Eq.28})$$

Assuming that, the image pixels are not converted to the gray scale variations, the image must be converted to the gray variations, as,

$$P_G[][] = \prod_{(r,g,v) \rightarrow gray} P[][] \quad (\text{Eq.29})$$

Further, for the centroid detection, the pixel pairs vectors, $Pix, Pair[][]$ is to identified, as

$$Pix_Pair[][] \leftarrow |P_G[x][y] - P_G[x+i][y+j]| \neq \phi \quad (\text{Eq.30})$$

Where, ϕ denotes the background pixels or the pixel from the background regions

Henceforth, the image pixel sets are ready to be converted into the coordinate mapping into coordinate vector, $Corr[][]$ as,

$$Corr[][] = \text{Iff } Pix_Pair[][] \neq \phi \quad (\text{Eq.31})$$

Furthermore, here from the $Corr[][]$ vector, the maximum intersection must be identified in order to determine the centroid, σ of the image, as by applying convolution techniques

$$\sigma[][] = \text{ConV}(Corr[][]) \quad (\text{Eq.32})$$

After the centroid extraction, the intensity calculation must be carried for the centroid, maxima region and minima region, as

$$\omega_C = \iint_{i,j} \sigma[i][j] \quad (\text{Eq.33})$$

$$\omega_{\min} = \iint_{i,j} \alpha_1[i][j] \quad (\text{Eq.34})$$

And

$$\omega_{\max} = \iint_{i,j} \beta_1[i][j] \quad (\text{Eq.35})$$

Where, ω_C, ω_{\min} and ω_{\max} are the intensity for each of the regions mentioned above.

Further, the intensity variation coefficient, η must be calculated as,

$$\eta = \frac{1}{\omega_C} \cdot \frac{|\omega_{Min} - \omega_{Max}|}{\Delta|\omega_{Min} - \omega_{Max}|} \quad (\text{Eq.36})$$

Finally, the depth of the defect, δ can be calculated as,

$$\delta = |\omega_{Min} - \omega_C| \cdot \eta \quad (\text{Eq.37})$$

Thus, the extraction of the defect depth is completed. The results obtained from this algorithm is elaborated in the further section of this work.

LEMMA -3: The width of the defect can be calculated using the maxima and minima points in the road condition information

PROOF: Assuming that spatial data set is denoted as SPD and each and every SPD is collection of the image, I_x and other data information $D[]$. Thus, this can be formulated as,

$$SPD = \langle I, D[] \rangle \quad (\text{Eq.38})$$

Further, the image component can be represented as collection of pixel information, $P[][]$, for n rows and m columns. This can be formulated as,

$$I_x = \sum_{i,j}^{n,m} P[i][j] \quad (\text{Eq.39})$$

Assuming that, the image pixels are not converted to the gray scale variations, the image must be converted to the gray variations, as

$$P_G[][] = \prod_{(r,g,v) \rightarrow gray} P[][] \quad (\text{Eq.40})$$

Henceforth, the image pixel sets are ready to be converted into the coordinate mapping into coordinate vector, $Corr[][]$ as,

$$Corr[][] = \text{Iff } P_G[i][j] \neq \phi \quad (\text{Eq.41})$$

Where, ϕ denotes the background pixels or the pixel from the background regions.

Henceforth, the width, ε , of the defect can be calculated as.

$$\varepsilon = \left| \prod_{Corr[\alpha][0]} P_G[i][j] - \prod_{Corr[0][\beta]} P_G[i][j] \right| \quad (\text{Eq.42})$$

Thus, the extraction of the defect width is completed. The results obtained from this algorithm is elaborated in the further sections of the work.

LEMMA-4: The area of the defect can be calculated using the coordinate vector from the road condition information.

PROOF – Assuming that spatial data set is denoted as SPD and each and every SPD is collection of the image, I_x and other data information $D[]$. Thus, this can be formulated as,

$$SPD = \langle I, D[] \rangle \quad (\text{Eq.43})$$

Further, the image component can be represented as collection of pixel information, $P[][]$, for n rows and m columns. This can be formulated as,

$$I_x = \sum_{i,j}^{n,m} P[i][j] \quad (\text{Eq.44})$$

Assuming that, the image pixels are not converted to the gray scale variations, the image must be converted to the gray variations, as

$$P_G[][] = \prod_{(r,g,v) \rightarrow gray} P[][] \quad (\text{Eq.45})$$

Henceforth, the image pixel sets are ready to be converted into the coordinate mapping into coordinate vector, $Corr[][]$ as,

$$Corr[][] = \text{Iff } P_G[i][j] \neq \phi \quad (\text{Eq.46})$$

Where, ϕ denotes the background pixels or the pixel from the background regions.

Finally, the area, A of the defect region can be calculated as

$$A = \frac{\text{Count}(Corr[][])}{|\text{Count}(P_G[][]) - \text{Count}(Corr[][])|} \quad (\text{Eq.47})$$

Thus, the extraction of the defect area is completed. The results obtain from this algorithm is elaborated in the further sections of the work.

LEMMA-5:

In the absence of the class determination factors, the pragmatic calculation of the ratio-based coefficients can form the determining factor.

PROOF : Assuming that, the parametric extraction of the dataset $DS[]$ is resulting into the minimum and maximum distance, DS_{Min} and DS_{Max} , depth of the defect, δ width of the defect, ε , and finally area of the defect, A . This can be formulated as

$$DS[] = \langle DS_{Min}, DS_{Max}, \delta, \varepsilon, A \rangle \quad (\text{Eq.48})$$

Further scaling up the first two parameters as,

$$\frac{\sum_{i=1}^n DS_{Min}}{\sum_{i=1}^n DS_{Max}} = \frac{\beta_2}{\beta_1} \quad (\text{Eq.49})$$

Or,



$$\beta_1.DS_{Min} = \beta_2.DS_{Max} \quad (Eq.50)$$

Again, with the first three parameters,

$$\sum_{i=1}^n DS_{Min} : \sum_{i=1}^n DS_{Max} : \delta = \beta_3 : \beta_2 : \beta_1 \quad (Eq.51)$$

Similarity,

$$\sum_{i=1}^n DS_{Min} : \sum_{i=1}^n DS_{Max} : \delta : \varepsilon : A = \beta_5 : \beta_4 : \beta_3 : \beta_2 : \beta_1 \quad (Eq.52)$$

Thus, the final determining factor, Υ can be formulated as

$$\Upsilon = \beta_0 + \beta_1.DS_{Min} + \beta_2.DS_{Max} + \beta_3.\delta + \beta_4.\varepsilon + \beta_5.A \quad (Eq.53)$$

Henceforth, with the detailed discussion on the mathematical formulation of the proposed solution, in the next section of the work, the algorithm is furnished and discussed.

VI. PROPOSEDALGORITHM -PRAGMATIC CLUSTERING

Henceforth, with the detailed understanding of the parallel research outcomes, formulation of the problems, and modelling of the proposed solutions, in the section of the work, the proposed algorithm is formulated.

Algorithm: Parametric Extraction and Pragmatic Clustering for Defect Detection (**PE-PC-DD**)

- Step - 1.** Accept the road condition information
- Step - 2.** Separate the image and coordinate information as I[] and SP[]
- Step - 3.** For all elements in I[] as I[i]
 - a. Apply gray scaling for I[i]
 - b. Apply segmentation for I[i] and store the objects as Obj[]
 - c. For each element in Obj[] as Obj[j]
 - i. Perform the coordinate mapping of the objects
 - ii. Extract Min and Max coordinate points
 - iii. Calculate the max distance between the objects and store in DS[]
 - iv. Identify the maximum intersection and centroid of the objects
 - v. Calculate the intensity of max, min and centroid points
 - vi. Identify the depth, based on intensity variation and store in DS[]
 - vii. Calculate the width of the defects from the coordinate mapping information and store in DS[]
 - viii. Calculate the area using the original and gray scale information and store in DS[]
 - d. For all elements DS[]
 - i. Identify the scaling factors

- ii. Based on the scaling factors, calculate the determining factor
- e. For all elements in DS[]
 - i. Apply clustering method of determining factor

Table-1 parametric extraction results

Bunch investigation itself isn't one explicit calculation, yet the general errand to be illuminated. It tends to be accomplished by different calculations that contrast essentially in their comprehension of what compromise a group and how to effectively discover them.

Mainstream thoughts of bunches incorporate gatherings with little separations between group individuals, thick zones of the information space, interims or specific factual circulations. Grouping can along these lines be defined as a multi-target improvement issue.

In the next section of the work, the achieved results from the proposed algorithm is elaborated.

VII. RESULTS & DISCUSSIONS

The proposed algorithm are evaluated on standard and benchmark datasets[12] and the results are highly satisfactory. In this section of the work, the obtained results are furnished and discussed.

Firstly, the results from the parametric extraction part of the algorithm is elaborated here[Table-1]

TABLE -I
Parametric Extraction Results

Dataset Element ID	Long Slope	Perpendicular Slope	Defect Number	Max Distance of the Defect (cm)	Depth of the defect (cm)	Average Width (cm)	Area (cm ²)
1	-0.21	4.71	1	250.46	122.23	88.89	22263
2	0.33	-3	1	199.22	65.21	43.06	8579
3	-0.21	4.7	1	976.34	266.06	241.2	235494
4	-0.3	3.29	1	402.39	189.53	49.69	19994
4	-0.15	6.78	2	246.64	182.18	36.94	9110
4	0.23	-4.3	3	278.23	185.52	27.47	7644
5	0.65	-1.54	1	166.98	99.18	55.89	9333
6	0.72	-1.4	1	907.43	648.38	397.55	360747
7	0.6	-1.67	1	602.82	692.67	167.89	101208
7	0.78	-1.28	2	870.4	755	308.03	268105
8	0.75	-1.33	1	1029.8	774.36	371.21	382272
9	0.17	-5.97	1	175.41	21.17	19.46	3413
10	0.45	-2.23	1	354.05	158.68	88.54	31347

As a speculation of this down to earth depiction, the arithmetic of differential math characterizes the slope of a bend at a point as the slope of the digression line by then. At the point when the bend is given by a progression of focuses in a graph or in a graph or in a rundown of the directions of focuses, the slope might be determined not at a point however between any two given focuses. At the point when the bend is given as a nonstop capacity, maybe as an arithmetical equation, at that point the differential analytics gives rules giving a recipe to the slope of the bend anytime in the bend.



A measurement space is a set for which separates between all individuals from the set are characterized. Along these lines, a wide range of sort of separations can be determined, for example, for traversal of diagrams, examination of conveyances and bends, and utilizing bizarre meaning of space.

Two unmistakable planes can either meet in atypical line or are parallel. Three planes, no pair of which are parallel, can either meet in a typical line, meet in a remarkable normal point or share no point for all intents and purpose. In the last case, the three lines of convergence of each pair of planes are commonly parallel.

Territory is the amount that communicates the degree of a two-dimensional figure or shape lamina, in the plane. Surface region is its simple on the two-dimensional surface of a three- dimensional item. Zone can be comprehended as the measure of material with a given of the shape, or the measure of paint important to cover the surface with a solitary coat.

The real time extraction results are visualized graphically here[fig-3 to Fig-6]

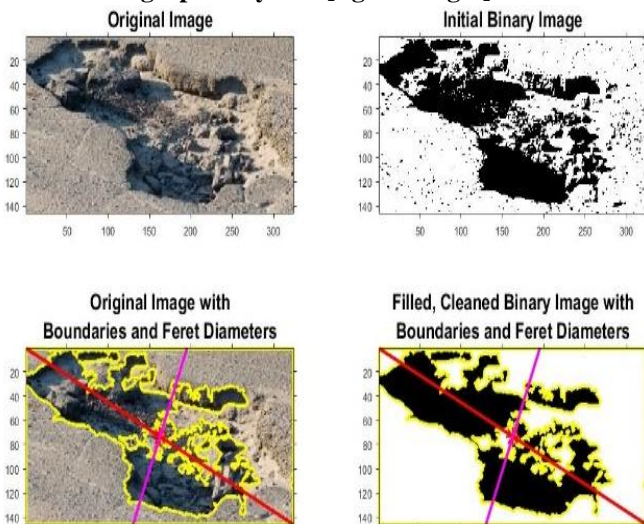


Fig. 2 Parametric Extraction of the Sample Set – 1

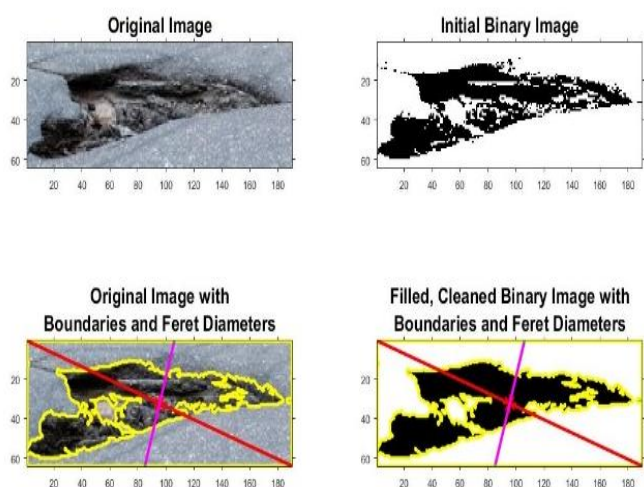


Fig. 3 Parametric Extraction of the Sample Set – 2

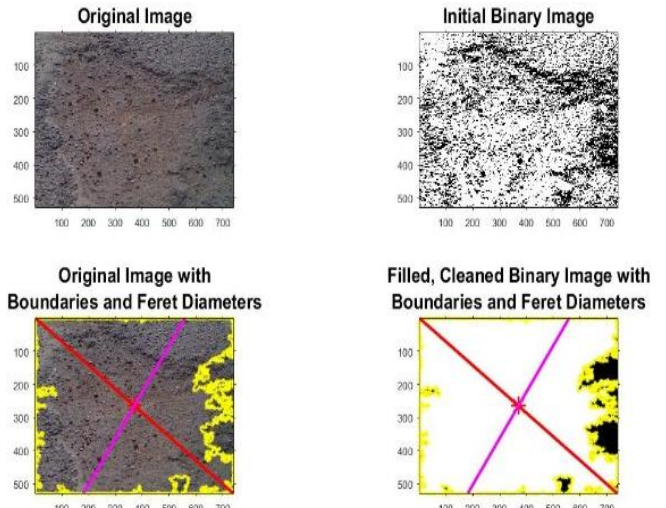


Fig. 4 Parametric Extraction of the Sample Set – 3

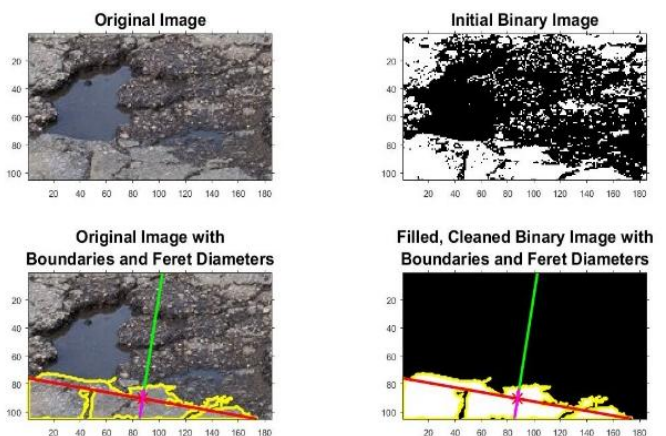


Fig. 5 Parametric Extraction of the Sample Set – 4

Secondly, the cluster analysis results are also furnished here [Table – 2].

TABLE II
CLUSTER ANALYSIS RESULTS

Elements	Complete Data	Cluster – 1 (Centroids)	Cluster – 2 (Centroids)	Cluster – 3 (Centroids)
Long Slope	0.2931	0.366	-0.2175	0.7125
Perpendicular Slope	-0.2492	-3.408	4.87	-1.42
Defect Number	1.3077	1.4	1.25	1.25
Max Distance of the Defect	496.9362	234.778	468.9575	852.6125
Depth of the defect	320.0131	105.952	190	717.6025
Average Width	145.8323	46.884	104.18	311.17
Area	112269.9231	12063.2	71715.25	278083
Class	Defects	Cracks	Patch	Pothole

The results are visualized graphically here [Fig – 7].

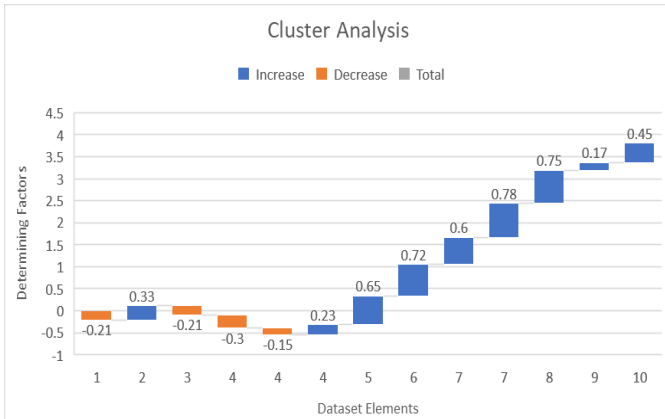


Fig. 6 Cluster Analysis

Finally, the accuracy analysis is carried out with the benchmark dataset[Table-3].

TABLE III
ACCURACY ANALYSIS

Dataset Element ID	Defect Number	Actual Defect Type	Identified Defect Type
1	1	Patchwork	Patchwork
2	1	Pothole	Pothole
3	1	Crack	Pothole
4	1	Crack	Crack
4	2	Pothole	Pothole
4	3	Pothole	Crack
5	1	Crack	Crack
6	1	Patchwork	Patchwork
7	1	Patchwork	Patchwork
7	2	Patchwork	Patchwork
8	1	Pothole	Pothole
9	1	Patchwork	Patchwork
10	1	Crack	Crack

For the sample size of 10 data items, the proposed algorithm demonstrates nearly 85% accuracy and for the complete dataset of 100 data items, the obtained accuracy is nearly 96%.Henceforth, after the detailed analysis of the results, in the next section of the work, the comparative analysis is presented.

VIII. COMPARATIVE ANALYSIS

After the detailed discussion on the algorithm and results obtained from the proposed algorithm, in this section of the work, the proposed methods are compared with the parallel research outcomes[Table-4]

TABLE -IV
COMPARATIVE ANALYSIS

Research Outcome	Methods Applied	Accuracy (%)
S. Kanarachos et al. [5]	<ul style="list-style-type: none"> Deep Learning Parameter Extraction Expert Systems 	89%
H. Bello-Salau et al. [6]	<ul style="list-style-type: none"> Parameter Extraction Sensor network Data accumulation 	92%
F. M. Bayer et al. [7]	<ul style="list-style-type: none"> Signal Processing Data Normalization 	90%
K. Azhar et al. [8]	<ul style="list-style-type: none"> Location aggregation Image Segmentation 	88%

PE-PC-DD	<ul style="list-style-type: none"> Parameter Extraction Pragmatic Clustering DefectCategory Separation 	96%
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For some random division of a picture, this plan yields the quantity of bits required to encode that picture dependent on the given division. Accordingly, among every single imaginable division of a picture, the objective is to discover the division which delivers the briefest coding length.

This can be accomplished by a basic agglomerative grouping strategy. The mutilation in the lossy pressure decides the coarseness of the division and its ideal worth may contrast for each picture.This parameter can be assessed heuristically from the complexity of surfaces in a picture are comparative, for example in cover picture, more grounded affectability and along these lines lower quantization is required.

IX. CONCLUSION

The growth in the road network in across all the places in India have motivated multiple researcher to automate the road maintenance activities. The road surface defects can be distinguished in few categories as crakes, potholes and patchwork. During the study this work, identifies that the extraction of the study this work, identifies that the extraction of the relevant parameters for the severity detection in the parallel research outcomes are missing and also the unsupervised learning methods are highly expected in case of the defect detection. Henceforth, this work deploys a set of models for the automatic identification of the road surface defects. Firstly, extraction of the coordinate values from the pixel information is used to determine the maximal and minimal distance between the objects in the road condition information. This helps in finding the surrounding information of the objects. Secondly, extraction of the intensity variation is used to produce the depth of the defects using the centroid estimation in the road condition information. Thirdly, the width of the defect can be calculated using maxima and minima points in the road condition information, this intern helps to develop the surface area of the defects. Fourthly, the area of the defect is used to be calculated using the coordinate vector from the road condition information. Finally, in the absence of the class determination factors, the pragmatic calculation of the ratio-based coefficients can form the determining factors, which intern generate the categorization of the defect and finally makes the repair process automate for making the road transport much safer and fast and better.

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