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Detection of Pavement Distress and its Types using Fuzzy C Means Algorithm

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Abstract: Pavements are broad spectrum of traffic levels, from two-lane rural routes to multilane interstate highways. It needs reformatory measures to restore safety. The common distresses on pavements are cracks, rutting, Potholes and some distresses. It causes the more accidents because of bad Pavement design. In this paper two steps are involved. The first step deploys the image enhancement that helps to enhance the image quality. Histogram Equalization is the one of the technique in image enhancement. That acts as a graphical representation of the digital image. The second step deploys Image clustering is a high-level description of image content FCM is one of the clustering technique and it separate the data into number of partitions. In this paper FCM is used to determine the pavement cracks. Using Otsu thresholding finds the distress types and lastly finds its severity level. Finally the performance parameter shows it gives a better result to identify the distress types and its level.

Keywords: Histogram Equalization, FCM, Otsu Thresholding, Crack Types.

I. INTRODUCTION

Pavements are always damage in many different ways. Pavement cracks detection is mostly performed by manually. Manually detecting the cracks and severity level is messy and time consumption process so the efficient image processing is the method that helps to determine the problems on the road and analyze its severity level. This must be useful for local councils and municipalities to cut out their difficulties in finding the cracks and prevent from the accidents. Enhancement accentuates or sharpens image features such as edges, boundaries, or contrast to make a graphic display more helpful for display and analysis. Histogram Equalization is common using enhancement technique. Histogram Equalization is the most important parts for any image processing. This process can be used on a whole image or just a part of an image. It can be used to improve the visual appearance of the image. Clustering is the search for distinct groups in the feature space. It is expected that these groups have different structures and that can be clearly differentiated. The clustering task separates the data into number of partitions, which are volumes in the n-dimensional feature space. Fuzzy c-Means Clustering performs clustering by iteratively searching for a set of fuzzy clusters and the associated cluster centre's that represent the structure of the data as best as possible. The algorithm relies on the user to specify the number of clusters present in the set of data to be clustered. Otsu thresholding is used to automatically perform clustering-based image thresholding or, the reduction of a gray level image to a binary image. The algorithm assumes that the image contains two classes of pixels following bi-modal histogram (foreground pixels and background pixels).

II. RELATED WORK

The number of recently published papers dealing with crack detection of surface distresses shows an increasing interest in this area. In this A hierarchical method present in[1] which deals with detection of roads and slopes. In this paper, a novel framework is proposed for segmenting road images in a hierarchical manner that can separate the following objects: road and slopes with or without collapse, sky, road signs, cars, buildings and vegetation from the images. The experiments show that the approach in this paper can achieve a satisfied result on various road images. The roads are unstructured, which are more complex than the structured roads. [2] road distress detection and classification system was used that can be applied to road which suffer from the problem of cracks as it as potholes. It was demonstrated that the system works it for the classification of the potholes as it as cracks. For that the classification has been performed with different sets of images and the performance of the system is evaluated. Several efforts have been made for developing a technology which can automatically detect and recognize potholes . Potholes classification can itll support a decision making system of pothole repair. Prewit edge detection method[3] was used for preprocessing as it proved to be the most efficient noise removal technique. Considering the results obtained after the analysis, it is concluded that 1^{St} order moment calculation and 2^{nd} order calculation are two parametric approaches that for the best efficiency for validation of the potholes form the considered samples of plain roads images as itll as potholes road images.

Paper[4]gives view about image-processing method for the crack detection of road pavement. A different method for the detection of road cracks has been introduced. A

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new evaluation and comparison method for automatic detection of road cracks. It considered pixels as for detection of cracks. The dimension of the distressed area such as width in case of longitudinal, transverse cracks, and miscellaneous cracks are digitally and manually measured. Pavement images and video data collected by digital inspection vehicles are revisited by technician on computer monitors in order to manually detect and assess potholes defects. [5]The method for automated potholes detection in asphalt pavement images is presented. In converted to grayscale. It is then histogram equalized. This is folloitd by thresholding and basic edge detection using sobel filter. Morphological operations such as dilation and eroding are performed and median filtering removing excess noise. A logical addition of the results obtained till then, results in a relative potholes shape. A structuring element allows for the potholes to b defined and open and a Skelton of the potholes is formed. Image processing techniques used for automated road anomalies using matlab.[6] The manual detection of road anomalies is costly and time consuming task. Many efforts are made to develop a technology to asses and recognize the road anomalies. In Paper a new unsupervised method based image processing and spectral clustering. [7]Spectral clustering to identify regions by using histogram-based data from grayscaled image. Data is collected by using in-expensive and omnipresent equipment mounted on passenger vehicles and off the shelf digital cameras for video acquisition. Thus, it is suitable for rough estimation of potholes, and it is cost effective because it uses in-expensive equipment.This paper[8] focusing on the detection of patches on images including pavement including pavement surfaces. The main assumption of the algorithm for identify patches lies on the fact that patches have greater grey intensities than their surrounding when presented in a grey scale images. Filtering histogram equalization and a method for filling holes is then applied for enhancing the contrast of the grey scale image and the contours are included in it. Finally the patch is detected based on a set of rules.

III. MOTIVATION AND JUSTIFICATION

In this paper proposed to enhance the contrast of the road image used histogram processing. Histogram Equalization is one of the method for enhance the contrast and it is also used to give it a better quality. Additionally cracks are detected by using clustering method. Clustering is common technique for detect the smaller groups into from larger groups. FCM algorithm yields good result for segmenting process. It has robust characteristics and can retrieve much more information and it is quite efficient than other clustering method. It improves the accuracy of clustering under noise. Otsu thresholding find the threshold that minimizes the weighted within-class variance. This turns out to be the same as maximizing the between-class variance.
Motivated by all these facts, this paper used the FCM method for detect the road cracks and the Otsu thresholding method is used for identify its severity level and crack types. Hence I justify that the Histogram Equalization with Clustering and thresholding technique is more suitable for this application.

IV. ORGANIZATION OF THE PROPOSED WORK

The remaining paper is organized as follows: Section V includes Methodology which includes the outline of the proposed work, Section VI includes the Experimental results, Section VII includes the Performance Analysis, and Section VIII includes the conclusion of the paper.
In this paper detect the cracks and identify its severity levels using clustering and Otsu thresholding methods has four steps there are:

1. Get the cracked image.
2.Apply enhancement technique Histogram Equalization.
3. Apply FCM method to detect the cracks portion.
4. Get a cracked portion.
5. Using Otsu thresholding to detect its types.
6. Obtain Severity Level.

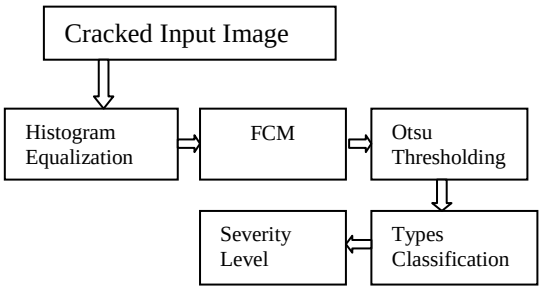

Fig1.Outline of proposed work

In figure 1 mentioned proposed work of this paper. Enhancement, clustering methods are applied into cracked image. Finally it detects the cracks and its types.

V. METHODOLOGY

a) Histogram Processing

Histogram processing is the act of altering an image by modifying its histogram. Common uses of histogram processing include normalization by which one makes the histogram of an image as flat as possible. This is also known as contrast enhancement. Intensity transformation functions based on information extracted from image such as enhancement, compression, segmentation and description. The Histogram of digital image with the intensity levels in the range [0, L-1] is a discrete function.
$h(rk) = nk$

Where
1. rk is the intensity value.
2. nk is the number of pixels in the image with intensity rk.
3. h(rk) is the histogram of the digital image with Gray Level rk

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Histograms are frequently normalized by the total number of pixels in the image. Assuming a M × N image, a normalized histogram.

$$P(rk) = \frac{number\ \ of\ pixels\ \ with\ intens\ ity\ \ \ n(k)}{total\ \ num\ ber\ of\ \ pixels}$$

p(rk)gives an estimate of the probability of occurrence of gray level rk.The Sum of all components of a normalized histogram is equal to1. Histograms are Simple to calculate in software and also lend themselves to economic hardware implementations, thus making them a popular tool for real-time image processing. Histogram equalization is a technique for adjusting image intensities to enhance contrast. The histogram equalized image g will be defined by

$$gi,j = floor\left((L-1)\sum_{n=0}^{fi,j} pn\right)$$

b) Fuzzy C Means

The Fuzzy C-Means algorithm (normally abbreviated as FCM) is basically an iterative algorithm that helps to find clusters in data and in which the idea of fuzzy membership is used. As an alternative of giving a pixel to a single cluster, each pixel can have distinctive membership values on each cluster. Fuzzy C-means (FCM) is a system of clustering which lets one piece of data to belong to two or extra clusters. This approach is most often used in recognition of pattern. This algorithm is an unverified clustering algorithm that is functional to quite many issues which involves classifier and clustering design, feature analysis. This algorithm has a number of applications like astronomy, geology, image analysis, chemistry, shape analysis, medical diagnosis, and recognizing of the target. The Fuzzy C-Means tries to catch clusters of pixel in the data by reducing the objective function as shown in the equation below:

$$J_m = \sum_{j=1}^{n}\sum_{i=1}^{c} u_{ij}^{m}\,||x_i^j - c_j||^2 \quad 1 \le m < \infty$$

where m is any real number greater than 1, u_{ij} is the degree of membership of x_i in the cluster j, x_i is the ith of d-dimensional measured data, c_j is th-dimension center of the cluster, and ||*|| is any norm expressing the similarity betiten any measured data and the center.Fuzzy partitioning is carried out through an iterative optimization of the objective function shown above, with the update of membership u_{ij} and the cluster centers c_j by:

$$Uij = \frac{1}{\sum_{k=1}^{C}\left(\frac{||xi - cj||}{||xi - ck||}\right)^{\frac{2}{m-1}}} \qquad Cj = \frac{\sum_{i=1}^{N} uijm\ .\ xi}{\sum_{1=1}^{N} uijm}$$

Many feature spaces can represent an image, and the FCM algorithm categorizes the image by making groups of identical data points in the feature space into clusters. This algorithm is obtained by iteratively reducing a cost function which is reliant on the displacement of the pixels to the centre of the clusters. The pixels on an image in the immediate neighborhood own the same feature data i.e. the pixels on image are correlated. Therefore, the association of neighboring pixels is an essential property that is of huge importance in image segmentation.

c) Otsu Thresholding

Thresholding is an important technique in image segmentation applications. The basic idea of thresholding is to select an optimal gray-level threshold value for separating objects of interest in an image from the background based on their gray-level distribution. While humans can easily differentiable an object from complex background and image thresholding is a difficult task to separate them. The gray-level histogram of an image is usually considered as efficient tools for development of image thresholding algorithms. Thresholding creates binary images from grey-level ones by turning all pixels below some threshold to zero and all pixels about that threshold to one. If g(x, y) is a threshold version of f(x, y) at some global threshold T.

g(x, y) = 1 if f(x, y) ≥ T= 0 otherwise

T = M [x, y, p(x, y), f (x, y)]

In this equation, T stands for the threshold; f (x, y) is the gray value of point (x, y) and p(x, y) denotes some local property of the point such as the average gray value of the neighborhood centered on point (x, y).

d) Obtain Severity Level

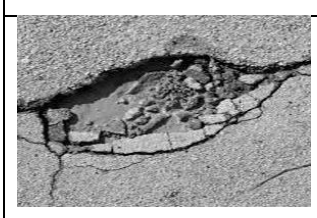
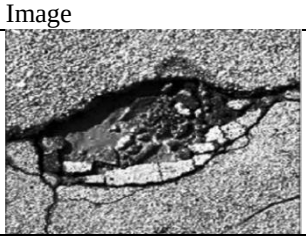
Get severity level, Otsu thresholding methos is used. Two thresholding methods are compared to the output Crack portion and input cracked image. If check the condition t1<t2, using these thresholding value finding the value. These threshold value is cpplied to cracked output portion image and input image and the connected component are identified.Then the morphological opening process is used to removing the short cracks on the road image.Finaly the cracked width is calculated

$$Width = \frac{TOTAL\ NUMBER\ OF\ PIXEL\ IN\ CRACK}{TOTAL\ NUMBER\ OF\ PIXEL\ IN\ THE\ CRACKS\ SKELTON}$$

VI. EXPERIMENTAL RESULT

It applied the FCM to colour images. The segmentation result as generated on different images then the output image is compared to the ground truth image which is already stored. Then the resulted images are shown below.

Table 1.Histogram Equalization

Input Image	Histogram Equalization Image
	

In above table 1 mention the input cracked image is enhanced by using histogram equalization Method. After the completion of enhancement processing the output image is applied into the segmentation Process.

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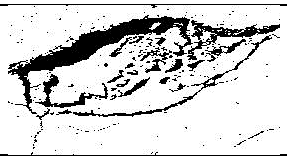
Table 2 Segmentation Output Images

Ground Truth Image	FCM
	

In above table 2 mentions the Segmentation output images. After the segmentation process is completed it get output images for Fuzzy C Means. imageis measure to the ground truth images.

VII. PERFORMANCE ANALYSIS

In this paper it proposed "Ground Truth" is a set of measurements. It is mostly applied to image segmentation. to test a system whose goal is to estimate parameters of the model. In such cases the ground truth is the known parameters model.

i) PERFORMANCE METRICS

a) True positive:

A true positive test result is one that detects the condition when the condition is present.

b) Sensitivity:

Sensitivity measures the ability of a test to detect the condition when the condition is present. Thus,

c) Specificity:

Specificity measures the ability of a test to correctly exclude the condition (not detect the condition) when the condition is absent. Thus,

d) Accuracy:

The comparison of a measurement with a known standard, used to determine whether the measurement is reliable. Measurement accuracy is identified as the difference between the measurement of a factor and the accepted value for that factor from a trusted external source, or the percentage by which the two values differ.

ii) PERFORMANCE EVALUATION

Table 3. Specificity and Sensitivity value

Image	Specificity	Sensitivity
Sample1	0.9781	0.8405
Sample2	0.9922	0.9268
Sample3	0.9892	0.9115
Sample4	0.9946	0.9477
Sample5	0.9907	0.8622
Sample6	0.9951	0.9417
Sample7	0.9860	0.8811
Sample8	0.9917	0.9358
Average	0.9897	0.9059

In table 3 mentions the sensitivity and specificity values. Using these two values calculates the accuracy. Then it defines which one is given the better accuracy in segmentation process.

Table 4. Severity Level

Image	Severity Level
Sample1	10.0352
Sample2	10.2009
Sample3	12.3743
Sample4	22.1573
Sample5	27.4562
Sample6	41.1665
Sample7	11.8047
Sample8	27.1725

In this table 4 mention the severity level of the pavement distress.Otsu thresholding method is used to identify the pavement distress types and its severity levels.

Table 5. Accuracy Value

Crack Types	Defective	Identified (TP)	Accuracy
Longitudinal crack	6	5	83.33
Miscellaneous Crack	5	4	80
Overall	11	9	81.81

In above table 5 mentions the defective portion of the cracked and how much of the defective portions are identified by these algorithm. Using these values it finds the accuracy level.

VIII.CONCLUSION

In this paper it applied Fuzzy C means the new distance approaches was proposed thus permitted to get a new variant of the FCM methods that is adopted more to the segmentation of images. It proposed the automatic detection of pavement distress using FCM. It show FCM is best method to identify the pavement distress. It detects the types of distress and obtain its severity level.

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