International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-9 Issue-5, January 2021

Classification of Building Images using Fractal Features

A. Sangeetha, R. Rajakumari

Abstract- ***Cracks in concrete buildings may show the total extent of damage or problems of greater magnitude. Causes of cracks depend on the nature of the crack and the type of structure. Crack classification is an approach to using machine learning algorithms to find a particular type of crack. The image is preprocessed by image smoothening and removes noise using a Gaussian filter, whereas the Sobel edge detection method is used to detect the edges. By using k-means clustering, the image segmentation is carried out to identify the Region of Interest. Fractal dimension is an efficient measure for complex objects. Fractal features like fractal dimension, average, and lacunarity are calculated using a differential box-counting algorithm. The classification of the crack classifies the crack based on the characteristics derived from the crack area.***

Keywords- ***crack classification; segmentation; narrow fractal features***

I. INTRODUCTION

The crack may be a complete or partial separation of concrete into more than two parts, formed by breaking or fracturing. Various surfaces where cracks can occur are buildings, bridges, roads, pavements, railway tracks, cars, tunnels, aircraft, etc. Generally, cracks can be divided into two classes, namely, positive and negative. The change in direction, distance, or depth occurs over a measured period of time in positive cracks, while in negative cracks, it remains constant. Both positive and negative cracks provide passage for moisture penetration if left unrectified, leading to potential damage. Longitudinal crack, transverse crack, crocodile crack, miscellaneous crack, and good cracks are reflected. The different forms of crack supported by its structure are micro crack, thin crack, sealed crack, mixed crack, line-like crack, minor crack, tiny crack, medium crack, big crack, and sophisticated crack. Rizvi Aliza Raza et al. addressed that there is a small crack in vehicle or aircraft applications[1], and more time is required for a single image so that it can not be identified from a single image. Romulo et al., [2] The color attribute extraction approach are used to distinguish outdoor images from desirable features (sky, grass). This approach classifies the color-based segmented window, particle filtering for particle selection, crack detection clustering, and the least square method with quantitative analysis for direction-based crack type classification.

Manuscript received on August 24, 2020.
Revised Manuscript received on January 28, 2021.
Manuscript published on January 30, 2021.

Ms.A.Sangeetha, Department of Computer Science and Engineering from National Engineering College, Kovilpatti, India.
Mrs.R.Rajakumari, Department of Computer Science and Engineering from National Engineering College, Kovilpatti, India.

Chen et al.,[3] Using wavelet transform and KD-tree, cracks from low-resolution images and discontinuities in the image are established. The Pseudo Ground Truth (PGT) and DSC (DICE Similarity Coefficient) rates defined by Rabihamhaz et al.

[4] are used for crack detection and assessment in the Minimal Path Selection (MPS) method. Preprocessing reduces the negative impact of non-uniform background and pavement markings, followed by morphological processing, which enhances the rear characteristics to differentiate sealed cracks within the pavement, discussed by Mojtaba et al.[5]. The Fuzzy clustering technique was identified by Nouha Ben et al.[6], which is useful when the input regions can not be clearly and precisely defined. For pavement crack precision, a combination of the Fuzzy clustering method, k-means thresholding, segmentation, denoising, morphological operation, and skeletonization provides an accuracy of 82 percent. Pengfeishi et al., 2017, reported that it is difficult to detect and identify the underwater dam's cracks. Therefore, to define the solar images and classify crack into small, medium, and large, the tensor voting method is used. Irrelevant objects identified by Wenyuet al.[7] are distinct from crack objects in subway tunnel crack detection. The author identified crack images that were prepared by S.Cho et al.[8], reducing errors in the approximate crack widths. Khalili et al.,[9] crack length was calculated using computer vision, provided by the author, and several methods and algorithms are presented. Dapeng Qi1 et al.[10] have defined that noise pixels are removed from the image according to the differences between noise and crack characteristics. Paul Zheng et al.[11] identified the crack measurements obtained from the digital measurements compared to the manual crack measurements taken and compared during testing; the percent difference between the crack's widths was less than 10 percent.H.N, H.N. Nguyen et al.[12] The approximate crack center lines were then obtained by thresholding the binary image with the filtered images and the morphological thinning algorithm. Author W.Zhang et al.[13]. Based on CMOS line scan cameras' application, crack detection, and classification technique for subway tunnels is implemented. Y.Kaewaramsri et al.[14] suggested the triangular box-counting method in which the traditional square box is divided into two triangles to improve box-counting accuracy. The author Bernieri et al.[15] discussed that several inverse procedures for Eddy Current Testing have been developed, typically requiring high-computational time and resources, hampering the use of 3D reconstruction.

II. METHODOLOGY

A. Dataset

The dataset contains concrete images having cracks. The dataset is split into two as negative and positive crack images for image classification. Each class has 20000images with a complete of 40000 images with 227 x 227 pixels with RGB channels.

For this work, 700 positive images and 600 negative images, a total of 1300 images, are taken for this experiment.

B. Preprocessing

Pre-processing is an initial step in image processing. Reading the original image and then those images are smoothened using the Gaussian filter for Noise detection and the Sobel method for Edge detection.

Gaussian Filter

Gaussian filtering is more effective at smoothing images. Gaussian filter is commonly used to reduce noise. The Gaussian filter is a non-uniform low pass filter. The image in the Gaussian filter is based on the increasing standard deviation. On increasing the standard deviation value, the blurriness of an image also gets increased.

Figure 1. Preprocessed Image

Edge Detection

For edge detection, the Sobel filter is used. To find object boundaries inside images. Sobel edge detection works by detecting discontinuities in brightness.

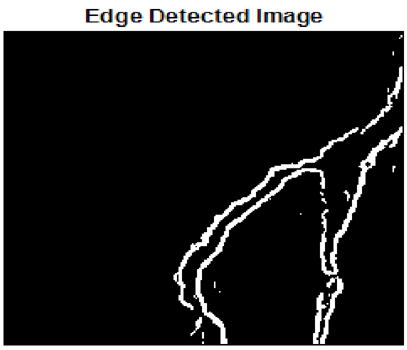

Figure 2. Edge Detection

C. Image Segmentation

K means clustering is used for image segmentation. K-means clustering will return cluster centroid locations and centers based on the given value.

imoverlay()- is used to burn binary mask into a 2D image

[I,cluster]=imsegkmeans(I,k)……(1)

where k is the number of clusters needed.

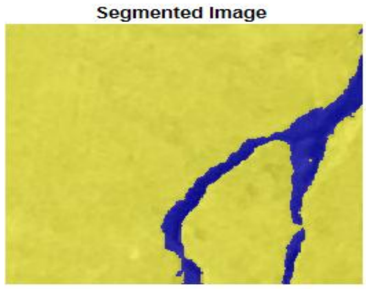

Figure 3. Segmented Imagedge Detection

D. Feature Extraction

The fractal dimension values are used for feature extraction. Fractal dimension average, Fractal dimension standard deviation, and Fractal dimension lacunarity are calculated for the selected area based on the formula. Selecting the particular area in the segmented image, and the values will be calculated based on the formula.

FDavg(j)= sum(ROI)/numel(ROI) ….(2)

FDsd(j)=std(ROI) ….(3)

FDlac(j)=((sum(ROI.^2)/(length (ROI)))./((sum(ROI)/(length (ROI)))^2))-1 ….(4)

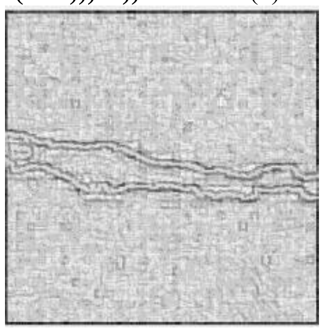

Figure 4. Feature Extracted Image

S.No	FD avg	FD SD	FD lac	Positive/Negative
1	1.516	0.6394	0.1778	0
2	1.4678	0.6953	0.2243	0
3	1.4679	0.7028	0.2292	0
4	1.6729	0.4763	0.0811	1
5	1.7163	0.4483	0.0682	1
6	1.7191	0.4365	0.0645	1

Figure 5. Feature Extracted Value

E. Crack Classification

Crack classification is a method using machine learning algorithms to find the particular type of crack. The crack classification classifies the crack supported by the feature that is extracted from the crack area. Using supervised learning algorithms, classification/prediction is carried out, while clustering is done. The various types of supervised learning algorithms applied for crack classification are Support Vector Machine (SVM), Naive Bayes, K Nearest Neighbors algorithm (KNN), Severe Learning Machine (ELM), Adaboost, and random forest.

Naive Bayes

Naive Bayes classifiers are for multiclass classification algorithms based on Bayes Theorem.

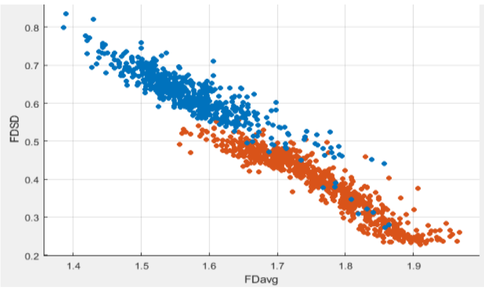

Figure 6. Kemel Naive Bayes

Support Vector Machine(SVM)

Support vector machine is for binary or multiclass classification.

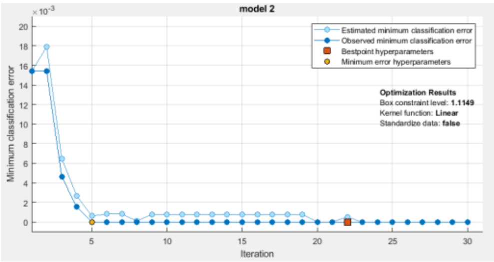

Figure 7. Support Vector Machine

III. EXPERIMENTAL RESULTS

TABLE I. NAÏVE BAYES AND SVM

	Naive Bayes	SVM
Accuracy	97.5%	99.7%
Prediction Speed	~4200 obs/sec	~56000 obs/sec
Training Time	3.5906 sec	2.704 sec

IV. CONCLUSION

The crack classification techniques accompanied by implementation are presented in this paper. Using sufficient quantitative metrics for crack classification, the findings must be evaluated. The accuracy of the Support vector machine gives the best result as 99.7 percent compared to Naive Bayes, as well as prediction time and training time is higher than the Naive Bayes in the support vector machine

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AUTHORS PROFILE

Ms.A.Sangeetha received her B.E degree in Computer Science and Engineering from National Engineering College, Kovilpatti, India. She is pursuing M.E degree, Kovilpatti.India. Her area of interest is Machine Learning and Deep Learning.

Mrs.R.Rajakumari received her M.E degree in Computer Science and Engineering from National Engineering College, Kovilpatti, India. She is pursuing Ph.D in AnnaUniversity,Chennai. Her research interest is Machine Learning and Deep Learning. She has published papers in National/International Journals and conferences.