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. 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. Pengfei 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 Q1 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.Kaewarmsri 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 20000 images with a complete of 40000 images with 227 x 227 pixels with RGB channels.
Classification of Building Images using Fractal Features

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

B. Preprocessing

Preprocessing 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 Image
dedge 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.

\[
\text{FDavg}(j) = \frac{\text{sum}(\text{ROI})}{\text{numel}(\text{ROI})} \quad (2)
\]

\[
\text{FDsd}(j) = \text{std}(\text{ROI}) \quad (3)
\]

\[
\text{FDlac}(j) = \frac{((\text{sum}(\text{ROI})^2)/(\text{length}(\text{ROI}))) - ((\text{sum}(\text{ROI})/\text{length}(\text{ROI}))^2))}{1} \quad (4)
\]

Figure 4. Feature Extracted Image

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. NAIVE 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.

REFERENCES

1. Rizvi Aliza Raza, Khan Pervez Rauf, Ahmad Shafeeq., 2016, "Crack Detection in Railway Track using Image Processing,” International Journal of Advance Research, Technology Ideas and Inventions., 3(4), pp. 489-496.
2. Romulo Gonçalves Lins and Sidney N. Givigi., 2016, "Image Analysis-based Automated Crack Detection and Calculation," IEEE Instrumentation and Measurement Transactions., 65(3), pp.583-590.
3. Yong Shi., Limeng Cui., Zhiqian Qi., Fan Meng., and Zhenmoug Chen., 2016, "Automatic Road Crack Detection using Random Structured Forests,” IEEE Transactions on Intelligent Transportation Systems., 17, pp. 3434 – 3445.
4. Rabih Amin., Sylvie Chambon., Jerome Idier and Vincent Baltazar., 2016, “Automatic Crack Detection on Two-Dimensional Pavement Images: An Algorithm based on Minimal Path Selection”, IEEE Transactions on Intelligent Transportation Systems 17, pp. 2718 – 2729.
5. Mojtaba Kamaliardakani., Lu Sun and Mostafa K. Ardakani., 2016, “Sealed-Crack Detection Algorithm using Heuristic Thresholding Approach”, Journal of Computing in Civil Engineering., 30
6. Nouha Ben Cheikh Ahmed., Samer Lahour., Chokri Souani., Kamel Beshes., 2017, “Automatic Crack Detection from Pavement Images using Fuzzy Thresholding”, International Conference on Control, Automation and Diagnosis., pp. 528 – 537.
7. Wenyu Zhang., Zhenjiang Zhang.,Dapeng Qi and Yun Liu., 2014, "Automatic Crack Detection and Classification Method for Subway Tunnel Safety Monitoring," Sensors., ISSN, 1424 - 8220, pp. 19307-19328.
8. H. Kim, E. Ahn., S. Cho, M.Shin., and S.-H.Sim, “Comparative analysis of image binarization methods for crack identification in concrete structures,” Cement and Concrete Research, vol. 99, pp. 53–61, 2017.
9. K. Khalili and M. Vahidnia, "Improving the accuracy of crack length measurement using machine vision", Procedia Technol., vol. 19, pp. 48-55, Oct. 2015.
10. Dapeng Qi1, Yun Liu1, Qingyi Gu, Fengxia Zheng An algorithm to detect the crack in the tunnel based on the image processing J. Comput., 26 (3) (2015)
11. Paul Zhong, Cristopher D. Moe’nCrack detection and measurement are utilizing image-based reconstruction Struct. Eng. Mater. (2014)
12. H.N. Nguyen, T.Y. Kam, P.Y. Cheng An automatic approach for accurate edge detection of concrete crack utilizing 2D geometric features of crack J. Signal Process. Syst. (2013), pp. 1-20
13. W. Zhang, Z. Zhang, D. Qi, and Y.Liu, “Automatic crack detection and classification method for subway tunnel safety monitoring,” Sensors, vol. 14, no. 10, pp. 19307-19328, 2014.
14. Y.Kaewwaramski, R. Worporatpanya, Improved Triangle Box-The Fractal Dimension Estimation Counting Process, in H. Unger, P. Meesad, S. Boomkrong (Eds.), Springer International Publishing, Recent Developments in Information and Communication Technology., 2015, pp. 53 - 61
15. A. Bernieri, G. Betta, L. Ferrigno, and M. Laracca, "Crack depth estimation by using a multi-frequency ECT method," IEEE Trans. Instrum. Meas., vol. 62, no. 3, pp. 544-552, Mar. 2013.
16. Ahmed Mahgoub Ahmed Talab, Zhangcan Huang, Fan Xi, Liu Hai Ming, Detection crack in the image using Otsu method and multiple filtering in image processing techniques, Optik – Int. J. Light Electron Opt. 127 (2016) 1030–1033.
17. L. Zhang, F. Yang, Y. Daniel Zhang, and Y. J. Zhu, “Road crack detection using deep convolutional neural network,” in Proceedings of the IEEE International Conference on Image Processing(ICIP ’16), pp.3708–3712, Phoenix, Ariz, USA, September 2016.
18. H. Oliveira and P. L. Correia, "Crackit—An image processing toolbox for crack detection and characterization," Proc. IEEE ICIP, pp. 798-802, 2014.
19. K. Fernandes and L. Ciobanu, "Pavement pathologies classification using graph-based features," Proc. IEEE ICIP, pp. 793-797, 2014.
20. 2018 — Ozgenel, Ç.F., Gönenç Sorguç, A. "Performance Comparison of Pretrained Convolutional Neural Networks on Crack Detection in Buildings," ISARC 2018, Berlin.

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.