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Article Title: Bridge Crack Detection Using Multi-SVM Classifier

Bridge Crack Detection Using Multi-SVM Classifier

M. Maheswari[1*], Mary Diana. S[2], G. Kharmega Sundararaj[3]

[1]Associate Professor, Department of Computer Science & Engineering, St.Peter's College of Engineering and Technology, Chennai, maheshwari.mnsnew@gmail.com

[2]Assistant Professor, Department of Information Technology, DMI College of Engineering, Chennai, diamarydiana@gmail.com

[3]Associate Professor, Department of Computer Science and Engineering, Dr. T. Thimmaiah Institute of Technology, KGF, Karnataka, megaminindia@gmail.com

ABSTRACT

The Automatic crack detection system is a significant technology to detect crack in concrete images. Identification of the crack Intensity and severity is the main objective of the detection system. Detection of images containing unwanted noises, blurriness and interference is considerably difficult hence image pre-processing is done using the adaptive filter by which the disturbances is removed. Images with non-uniform light, poor contrast or sudden brightness changes is rectified in the segmentation process using the fuzzy-c algorithm that uses clustering technique. Techniques like Gray scale processing do not provide accurate detection therefore Gray level co-event matrices (GLCM) technique which extracts high level features needed in order to perform classification of images and Multi support vector machine (SVM) is used because they can handle multiple continuous and categorical variables. The proposed technique provides better outcomes for crack detection and treatment. The PYTHON software is utilized.

Keywords: Adaptive filtering, Fuzzy-c algorithm, GLCM technique, SVM classifier.

1 Introduction

Civil structures such as roads, bridges, pavement and building is often exposed to real tension due to the natural calamities like earthquake, daily usage or over usage such calamities causes a structural change or damage to the components called cracks. Normally cracks are minor sized that appears on the surface of the structures when they are un-noticed these cracks spreads across the surface and cause severe damages to the fatalities. Manual methods of crack detection uses human experts. However this method is highly time consuming and requires extensive labours. Therefore by using automation crack detection, crack type, length, breadth, and depth of the crack is identified in a fast and effective way. Cracks affects the load carrying capacity and causes severe damages hence these cracks need to be detected at the early stage to minimise the damage rate but manual methods of crack detection uses human experts who visit the damaged cites to verify the crack intensity and severity using man-made tools. However this method is highly time consuming and requires extensive labours. Therefore by using automation crack detection: type, length, breadth, and depth of the crack is identified in a fast and effective way. Clustering plays an important role in crack detection for longitudinal,

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and alligator cracks but clustering methods struggle with data noise, identification of crack type, algorithm selection, large-scale data, and real-time processing [1]. Technical process like histograms of oriented gradients (HOGs) and uniform local binary patterns (ULBPs) are used to extract features from a dataset containing non cracked and cracked images covering different patterns of cracks and concrete surface. These techniques are used for inspecting and monitoring bridge cracks in real-time however this method is considered in-accurate [2]. For accurate crack detection modified LeNet-5 model is used which highlights the areas of crack and non crack using red and green colour but the results are considered average [3]. Crack segmentation is employed using deep convolutional neural network (CNN) architecture which eliminates the effect of gradient problems [4]. CNN is not suitable for detecting cracks in masonry structure like walls, columns, beam foundations and low bearing arches [5].

CNN method classifies the cracks first and then detect the crack images but this method do not include Image preprocessing techniques therefore the images contains unwanted noises and poor contrast [6]. To achieve this image pre-processing is done using the adaptive filter which enhances the poor contrast of the image [7]. Crack width transform (CWT) technique is used for automatic detection and accurate width measurement of cracks in concrete. CWT detects crack with greater accuracy and consistency compared with the conventional technique [8].Deep convolutional generative adversarial network (DCGAN) and You Only Look Once v5 (YOLOv5) is used for a fast and accurate image processing which is highly cost efficient [9]. For effective classification and interpretation Naive Bayes classifiers is employed to detect affected areas which shows the age, depth and severity of the crack by using the impact echo data however this classifier only shows 10% of the impact echo signal are usable [10].

To solve this problem, Crack detection system consisting of the following processes is introduced. Firstly the raw image is pre-processed using adaptive filtering and then segmented using the Fuzzy-c algorithm following that the poor contrast of the image is enhanced by the feature extraction process that is carried out by Grey Level Co-occurrence Matrix and to detect crack with maximum accuracy Multi SVM classifier is chosen for the classification.

2 Recent Works

Shengyuan li *et al* [2020] [11] have introduced a crack detection system on convolutional encoder-decoder network (CedNet) which detects crack intensity and severity by using image pre-processing. The bias parameters and weight is initialised to cedNet using the strategy transferring technique. Therefore by using cedNet the length, breadth and depth of the crack is detected. Despite this cedNet cannot detect thin cracks and the accuracy rate need to be increased.

Mohammad Shahin *et al* [2024] [12] have implemented a Visual Transformer (ViT) model that is enhanced using the detection algorithms which enables crack detection with high time maintenance and minimal production cost. Nonetheless this system do not provide image pre-

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processing hence adaptive filtering need to be used to rectify the disturbances in the concrete images.

Prashant kumar *et al* [2021] [13] have developed a crack detection system based on machine learning and advanced deep learning techniques which consist of computing model You Look Only Once-version3 (YOLO-v3) with high speed algorithms to detect the length, breadth and depth of the crack. However this system cannot detect all types of cracks. Therefore a classifier need to be enhanced to classify the cracks types.

Wenting Qiao *et al* [2021] [14] have developed a crack detection system based on expected maximum attention EMA-DenseNet is used for the bridge damage feature extraction. EMA algorithm can detect crack and steel corrosion at the bottom of the bridge with fast processing speed. Therefore by using EMA-DenseNet the intensity and severity of the crack and the steel corrosion is detected. Despite this DenseNet struggle with computational and memory deficiency. Hence segmentation need to be done using the GLCM.

Zhun Fan *et al* [2020] [15] have developed convolutional neural networks (CNN) system for automatic crack detection in pavements by using pooling layers method for higher accuracy. Therefore CNN detects the severity and crack type. However this network does not provide end-to-end detection and can detect only static images. Hence the SVM classifier need to be used.

3 Proposed Work Explanation

Crack detection using a SVM classifier is used to detect the orientations of the crack with the concrete images. Original form of the images contains unwanted noises and disturbances therefore the input image is enhanced using an adaptive median filter during the pre-processing stage. After the pre-processing stage images with poor contrast and sudden brightness changes is rectified using Fuzzy C means algorithm-based segmentation. Grey scale algorithm which is in use detects unaffected areas also as cracks to overcome this feature extraction is done using the morphological operation and the Grey Level Co-occurrence Matrix and hence this system detects crack with high accuracy.

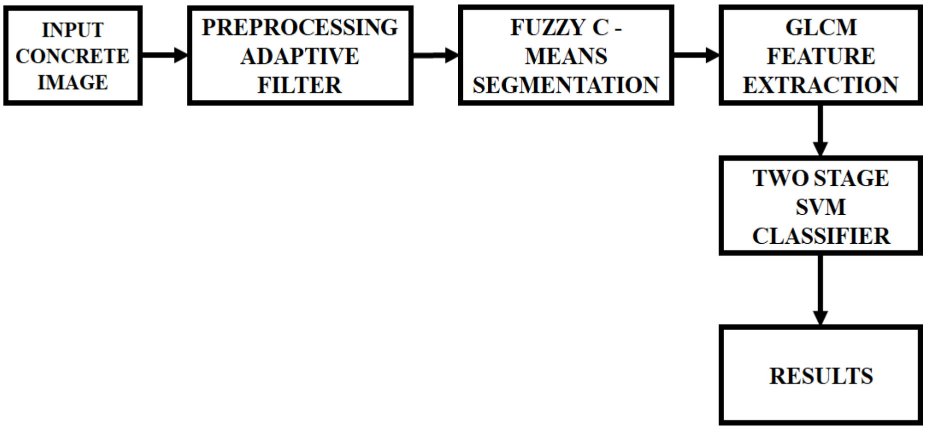

Figure 1: *Process Flow Diagram*

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3.1 Pre-processing

Adaptive filter is mainly used to remove the unwanted noises and blurriness. These filters examine original signal and remove noise with the deterministic signal. Adaptive filters continuously change their response in order to satisfy the given condition. They are capable of learning from the statistics of current conditions and change their coefficients in order to achieve a certain goal. A system is said to be adaptive if it alters its filtering functions based on the input given condition.

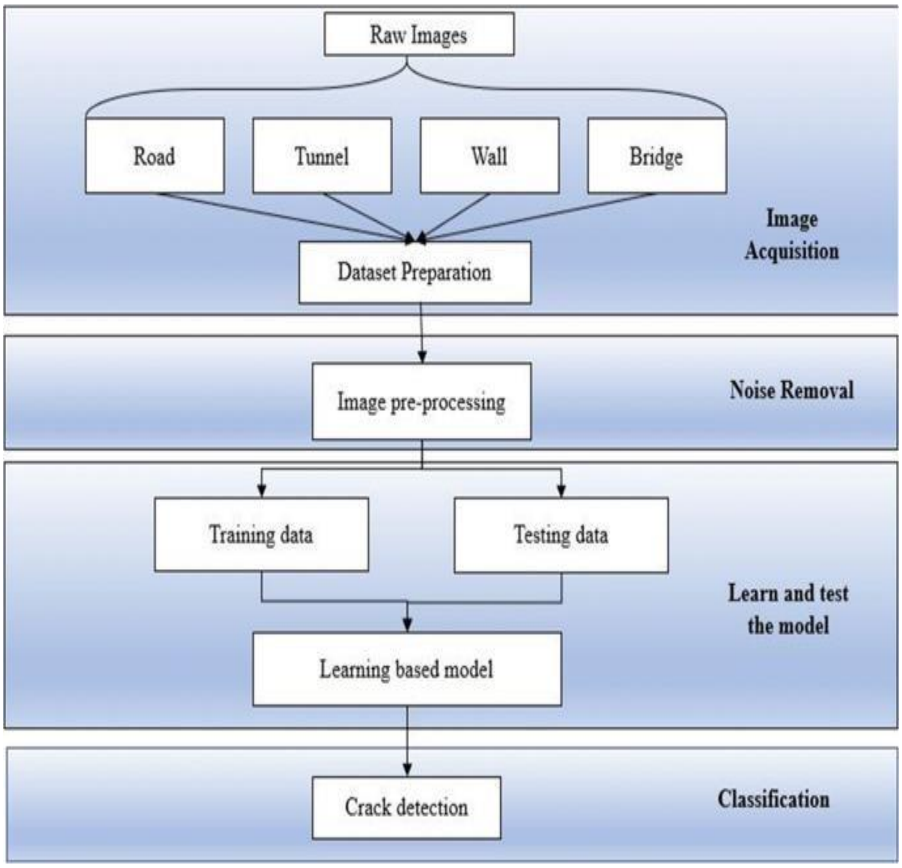

Figure 2: *Image processing for crack detection.*

3.2 Segmentation

Image segmentation is the process that subdivides an image into its constituent parts or objects. In this system, Fuzzy-C-Means (FCM) algorithm is used for segmentation, which reduces the complexity of the image. Fuzzy-c algorithm functions based on the clustering techniques where a data set is grouped into N clusters with every data point in the dataset belonging to every cluster.

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3.3 Feature Extraction

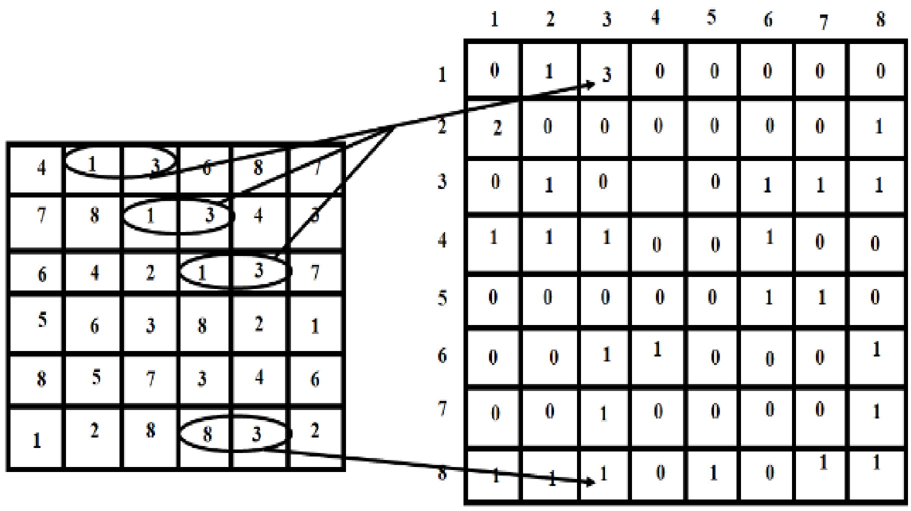

Figure 3: *GLCM operation*

Feature extraction is a particular kind of dimensionality modification. The chief purpose of this technique is to capture the important characteristics of the raw data and interpret this character in a less dimensionality space. The methods for feature extraction is grey level co-occurrence matrix (GLCM) which contains the second-arrange measurable data of spatial association that is pixels of an input image.

3.4 Classification

SVM classifiers are learning algorithms that is used for both classification and regression which is mainly used because of their ability to handle multiple and continuous variables. SVM divides data set into classes to find maximum hyperplane that has the largest distance to the nearest training data point of any class. The real power of this algorithm depends on the kernel function being used. The most commonly used kernels are linear kernel, gaussian kernel, and polynomial kernel.

4 Results and Discussion

Figure 4: *Input Image*

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Figure 4: Displays the unprocessed concrete image

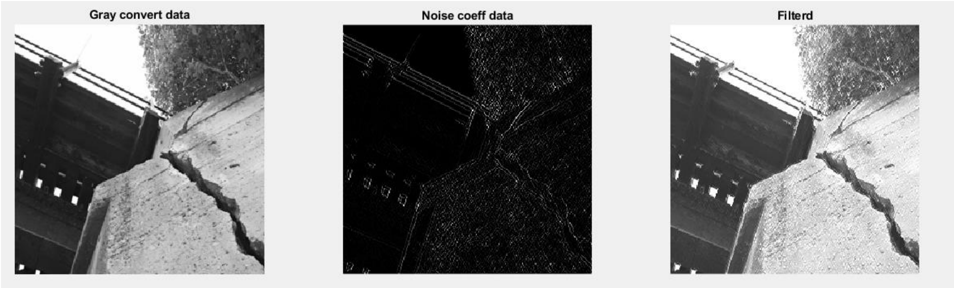

Figure 5: *Pre-processed image*

Figure 5: Represents the pre-processed image where the unwanted noises and disturbances is removed using the adaptive filtering.

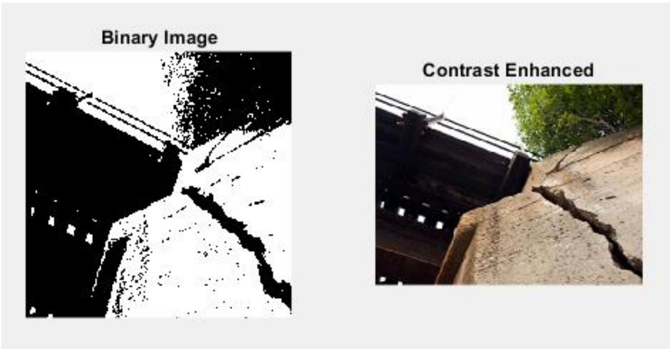

Figure 6: *Segmented image*

Figure 6: displays the segmentation process where the poor contrast and bad lighting of the original image is enhanced.

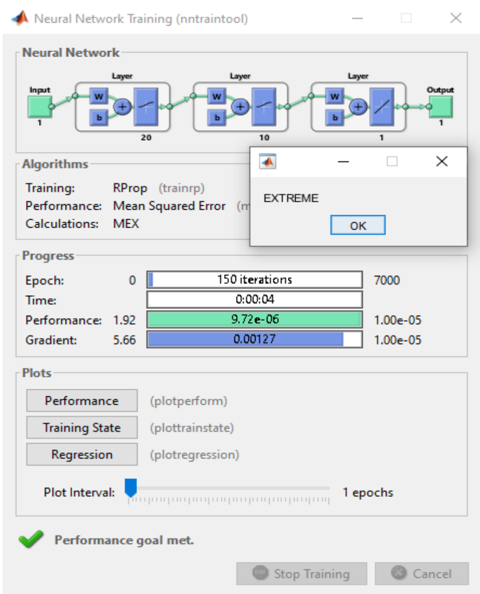

Figure 7: *Multi SVM classifier result.*

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Figure 7: shows multi SVM classifier result. It plots the time, performance and predict the level of cracking.

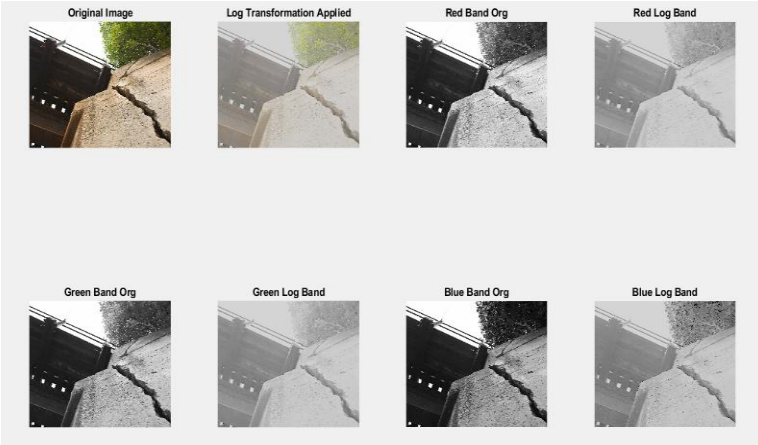

Figure 8: *Multi SVM classifier*

Figure 8: displays multi SVM classifier. This image shows four types of cracked images

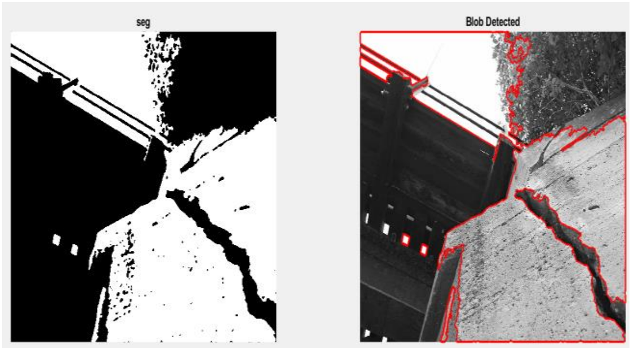

Figure 9: *Multi SVM classifier results in cm.*

Figure 9: represents the results obtained by the SVM classifier with accurate bridge crack detection.

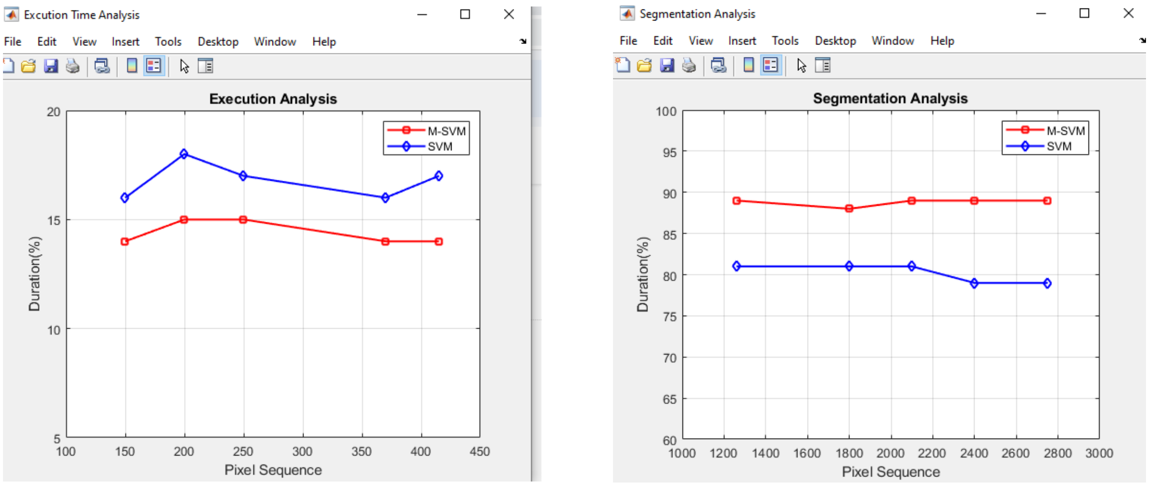

Figure 10: *Execution and segmentation analysis*

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Figure 10: represents the Execution and segmentation analysis

5 Conclusion

Detection of crack with high accuracy is the main objective of the developed system that is accomplished by using the Multi Support Vector Machine (SVM) classifier which is employed to perform detection among large number of images with high processing speed. Thus with the obtained results using Multi SVM, the type of crack was detected and analysis is done to provide suitable technique to treat the crack to enhance the durability and strength.

References

1. Choi; Young; Hee Won Park; Yirong Mi; Sujeen Song, Year: 2024 "Crack Detection and Analysis of Concrete Structures Based on Neural Network and Clustering." Sensors, vol: 24, no: 6, pp.1725.

2. Li; Ying; Peng Duan, Year: 2019, "Research on the innovation of protecting intangible cultural heritage in the" Internet Plus" Era." Procedia Computer Science, vol: 154, pp.20-25.

3. Zoubir; Hajar; Mustapha Rguig; Mohamed El Aroussi; Abdellah Chehri; Rachid Saadane, Year: 2022, "Concrete Bridge Crack Image Classification Using Histograms of Oriented Gradients, Uniform Local Binary Patterns, and Kernel Principal Component Analysis" Electronics, vol: 11, no: 20, pp. 3357.

4. Billah; Umme Hafsa; Hung Manh La; Alireza Tavakkoli, Year: 2020, "Deep Learning-Based Feature Silencing for Accurate Concrete Crack Detection" Sensors, vol: 20, no: 16, pp. 4403.

5. Hallee; Mitchell J; Rebecca K. Napolitano; Wesley F. Reinhart; Branko Glisic, Year: 2021, "Crack detection in images of masonry using cnns," Sensors, vol: 21, no: 14, pp. 4929.

6. Cho, Hyunwoo; Hyuk-Jin Yoon; Ju-Yeong Jung, Year: 2018,"Image-Based Crack Detection Using Crack Width Transform (CWT) Algorithm," in IEEE Access, vol: 6, pp. 60100-60114.

7. Arunish Kumar; Amit Kumar; Avinash Kumar Jha; Ashutosh Trivedi, Year: 2020,"Crack Detection of Structures using Deep Learning Framework," 2020 3rd International Conference on Intelligent Sustainable Systems (ICISS), Thoothukudi, India, 2020, pp. 526-533.

8. Zhong Qu; Jing Mei; Ling Liu; Dong-Yang Zhou, Year: 2020, "Crack Detection of Concrete Pavement with Cross-Entropy Loss Function and Improved VGG16 Network Model," in IEEE Access, vol: 8, pp. 54564-54573.

9. Liu; Yifan; Weiliang Gao; Tingting Zhao; Zhiyong Wang; Zhihua Wang, Year: 2023, "A Rapid Bridge Crack Detection Method Based on Deep Learning" Applied Sciences, vol: 13, no: 17, pp.9878.

10. Jafari; Faezeh; Sattar Dorafshan, Year: 2021, "Bridge Inspection and Defect Recognition with Using Impact Echo Data, Probability, and Naive Bayes Classifiers" Infrastructures, vol: 6, no: 9, pp. 132.

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Article Title: **Bridge Crack Detection Using Multi-SVM Classifier**

11. Li; Shengyuan; Xuefeng Zhao; Year: 2020, "Automatic crack detection and measurement of concrete structure using convolutional encoder-decoder network," IEEE Access, vol: 8, pp. 134602-134618.

12. Shahin; Mohammad; F. Frank Chen; Mazdak Maghanaki; Ali Hosseinzadeh, Neda Zand; Hamid Khodadadiear, Year: 2024, "Improving the Concrete Crack Detection Process via a Hybrid Visual Transformer Algorithm." Sensors, vol: 24, no: 10, pp. 3247.

13. Kumar; Prashant; Supraja Batchu; Solomon Raju Kota, Year: 2021, "Real-time concrete damage detection using deep learning for high rise structures," IEEE Access, vol: 9, pp. 112312-112331.

14. Qiao; Wenting; Biao Ma; Qiangwei Liu; Xiaoguang Wu; Gang Li, Year: 2021, "Computer vision-based bridge damage detection using deep convolutional networks with expectation maximum attention module," Sensors , vol: 21, no: 3, pp. 824.

15. Fan; Zhun; Chong Li; Ying Chen; Paola Di Mascio; Xiaopeng Chen; Guijie Zhu; Giuseppe Loprencipe, Year: 2020, "Ensemble of deep convolutional neural networks for automatic pavement crack detection and measurement." Coatings, vol: 10, no: 2, pp. 152.