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Crack Detection Using Image Processing:Review

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Abstract: **The deterioration of structures due to cracks is one of the major issues in large construction site, exclusively where manual inspection is not possible. In such cases, a novel idea is proposed which integrates an Unmanned Aerial Vehicle (UAV's), image processing techniques and data acquisition which helps in monitoring of construction. The stated purpose of using an UAV with camera mounted on it is to reach it to the inaccessible areas and strengthen the crack detection more precisely by acquiring images from it. Literature presents morphological image processing technique to identify the cracks. Research also focuses on the various image processing techniques used to detect crack. Based on the review, analysis is done and a suitable conclusion is drawn. This approach has helped in elevating our control over manual inspection.**

I. INTRODUCTION

Cracks are an important indicator when it comes to the safety of an infrastructure. Effects such as cyclic loading, fatigue stress develop internal stresses in the structure and leads to the development of cracks. In addition, effects like thermal expansion and contraction, human damage and surface changes transcend material discontinuities which lead to failure. To prevent this damage a Crack detection process is employed. The crack detection can be done using two ways: (1) Manual Inspection (2) Automated Inspection. In conventional methods, manual inspection was done by set of skilled inspectors with the help of surveying instruments and visual examination to detect the irregularities and defects in the structure. However, this method has certain drawbacks, as it is impossible for a crew to detect the cracks in inaccessible areas such as large dams, monuments, buildings, etc. and also the estimation of size, length and width of the crack.

In order to get images of the structure in a required manner there is a need of a high resolution camera to get desired results through image processing. Because of its accuracy and simplicity in its results many of the image processing techniques were proposed. Image processing techniques such as Morphological approach, Hough transform, Edge detection Dijkstra's algorithm, Neural Network, Statistical approach, Segmentation are the process that have been focused in this literature. Softwares like image processing lab, Open CV and MATLAB Graphical User interface can be developed for easy monitoring and real time inspection through which data can be extracted.

Initially the structure of the image processing based crack detection is proposed.

- Crack detection using image processing: Structure

The steps involved in image processing techniques are as follows: (1) Acquisition of an image with the help of a camera as a crack image as an input. (2) After acquisition the collected images go through pre-processing where it undergoes processes such as scaling and segmentation.(3)In colour image processing ,some of the techniques are employed to process the deducted image.(4) Finally, the feature extraction of image is done to obtain the shape of the crack.

II. LITERATURE REVIEW

This section provides an overview of all the image processing techniques and the algorithms used for the detection of cracks mostly in engineering structures.

E. Balasubramanian et al. [1] have proposed a technique that integrates Hat-transform and HSV thresholding for crack detection. They have proposed an algorithm which combines the output of the two filters resulting in enhancement of an output image. It was based on mathematical morphological approach and their study showed

that bottom hat transform was able to identify the cracks more easily than the Top-hat transform. The former method was then combined with the HSV thresholding which gave precise output of the cracks. In their methodology they used a novel idea which uses an UAV (Unmanned aerial vehicle) for detecting the cracks in real time. They developed a GUI in Matlab that enabled them to detect and identify the cracks in real time thereby saving the computational time.

Shivaprasad K et al. [2] have proposed a simple technique to detect cracks in pavements such as roads and concrete structures. They used normal edge detection algorithm as a primary step as a pre-processing part to detect the false edges

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of the crack. The false edges were removed by using morphological approach. The drawback of the method was the obtained output images contained false edges which increased noise in the images. Proposed method was well suited for the pre-dominant cracks. As an extension to their method they also used thresholding technique ,and the obtained results were good.

Anders Landster``om et al. [3] conducted experiments on steel slabs for determination of cracks based on morphological technique. The study focuses on 3D surface profile data collected by laser triangulation based on morphological technique. Two sets of A and B of 3D profile were taken.

The data was processed in regions in the form of images of 150 mm x 100 mm (width x length, or X x Y) in size. The performance of the given method was verified by segmenting and classifying a second independent validation set B, containing 323 regions of 3D surface data collected from four different steel slabs. The results obtained were satisfactory leading to the collection of data nearly at 90% crack probability. The attractive result of their investigation was due to statistical classification and automated morphology method.

Gunkel et al.[4] have designed a crack detection algorithm .The micro cracks are detected using shortest possible path in crack clusters which also follows the darkest parts .They used Dijkstra's algorithm to detect the crack path which enabled in analyzing kinks and curves of the crack. The method was implemented in C and R programming language package which provided accurate results.

Kammar et al.[5] have proposed a system for road crack detection and characterization to minimize the human involvement. In this type of imaging, they used Hough transformation for crack detection and supervised method for the characterization of crack which is based on block-based image analysis approach. For each pixel the Hough transform determines the straight line of that pixel and calculates the slope of the line by mapping Cartesian coordinate into rotational coordinate system. Based on the obtained results the cracks were classified and this two-step approach proved to be robust.

Pathak et al.[6] have presented a fuzzy logic approach for crack detection which is an alternative for non-destructive test. They used natural frequency of the cracks in a beam as an input to the fuzzy logic. The relative output obtained was the crack depth and relative position of the crack. Accordingly, the fuzzy controller was prepared for varying natural frequencies. At the end, they [6] were able to predict the location of the crack and crack depth within nanoseconds which saved computational time.

Zhang et.al[7] supervised the subway tunnel using Complementary Metal Oxide Semiconductor camera .

The captured images were stored in digital images. For extracting the data from the images they studied and formulated an algorithm using morphological and thresholding technique. The extracted images were compared with grayscale images and they found that over 90% of crack length is preserved in the last output image of binary images. Additionally, the algorithm bottom hat transform proposed by them helped them for the classification and crack detection purpose. The experimental results were based on different parameter settings which showed that high accuracy can be obtained by using different types of classifiers. However, their experiments were subjected to eclectic cracks. These techniques were applicable for the cracks of split width greater than 0.3mm and object length greater than 15cm, which was the drawback of the project.

Arun Mohan, Sumathi Poobal [8] presented a review on the analysis of types of imaging processing techniques used for crack detection. They surveyed several image processing techniques such as wavelet transform, median filtering, Hat transform. Morphological approach, Gabor filtering, Otsu's method, Statistical method, Superpixel algorithm, Data fusion filtering, Hough transform, Ultrasonic pulse velocity technique. Based on the analysis they focused their review on five features. Firstly, it was an objective based feature which consisted width of the crack, length of the crack and direction of propagation of the crack.

Secondly, they analyzed the data sets used in the methods for calculating real data and thereby making it more efficient. Additionally, they presented the methods which provided high accuracy. Finally, they performed the analysis of each image processing techniques used in each system. Based on their analysis they concluded that the camera based image detection with algorithms such as thresholding and morphological technique proved to be efficient.

III. ANALYSIS AND DISCUSSION

This section covers the analysis of the crack detection using image processing techniques based on the literature reviewed.

Based on the paper reviewed, it was observed that Morphological approach was used in almost all the papers [1, 2, 3] and [7].The family of operations associated with it(thickening , dilation, erosion, Hat-transform, opening and closing) performed on on the shape of the subject of an image is known as morphological approach. For robust results the Hough Transform was used[5]. Due to its desirable features and real time inspection Hough transform are used for object recognition. Moreover the statistical approach proved to be efficient and accurate for data analysis and filtering of images[5].For reduced computational time ,fuzzy logic [6] is suitable method which predicted the cracks in nanoseconds. For easier segmentation of images in pre-processing stage techniques like HSV thresholding were adopted which enhanced the quality of image making it more identifiable. Finally, analysis based on the image processing techniques reviews the fact that the productivity of image processing techniques were introduced only in the post-processing.

IV. CONCLUSION

This paper provides detailed survey of the image processing techniques used to detect cracks in engineering structures. The main intention of the study was to review papers and analyse the best technique that could be used for crack detection. Based on the paper reviewed we conclude that the image processing techniques such as Morphological and Thresholding are the most suitable for crack detection.The objectives such as width,depth,length and direction of propagation of crack can be analysed. The segmentation of images grouped into set of data give better and accurate results. An automated based UAV image processing proves to be efficient to detect the cracks in real time thereby reducing human efforts and reaching

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inaccessible areas easily. The literature encourages us to study more on UAV's and thermal infrared cameras which could help to make the system efficient and error free.

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