Image Processing Techniques in context to automatic crack surface recognition and associated challenges

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Abstract **:Crack on the solid are one of the primary pointers of structures which will lead genuine harm in the entire framework. Several activities still involve human interference and assessment which are pricey and time consuming as well as accuracy of the crack detection might be compromised. In traditional way, crack detection is carried out manually or via instruments like microscopes which leads to discrimination. The entire process is cumbersome, time consuming, less efficient and compromise the judgment. Automatic Image analysis system for the crack detection is the solution of above constraints. This paper delineates the importance of automatic image analysis system for the crack detection. The paper contains the comprehensive literature survey of image processing techniques in the context to concrete surface crack detection. The paper also describes the analysis of important image processing techniques based on literature survey. At last, paper delineates research gaps and challenges of existing research work.**

Keywords: Digital image Processing, Concrete surface, Crack.

Introduction

Concrete cracks are important in term of infrastructure security. An impact such as cyclic loading, fatigue strain in the system induces internal tension and causes cracks to develop. Therefore, effects such as thermal expansion and contraction, human damage and changes in the ground overcome material discontinuities that result in failure. A system of Crack detection is used to prevent this damage. There should be two different ways to detect crack: (1) Manual Inspection (2) Automated Inspection. In conventional methods, manual inspection was conducted by collection of expert reviewers to detect irregularities and defects in the design with the aid of surveying instruments and visual evaluation. This technique has some disadvantages, however, as it is difficult for a crew to locate cracks in inaccessible areas such as massive dams, parks, homes, etc., as well as measuring the crack's volume, length and width. For accuracy, crack detection should be achieved correctly by calculating the crack measurements. Human inspection is time consuming so automatic crack detection methods are vital due to their better processing speed than human inspection.

Image processing is very suitable technique for automatic crack recognition and analyses. Image processing based methods are classified as (a) Integrated Algorithms (b) Morphological Approach (c) Percolation based Methods and (d) Practical Techniques [19]. The main advantage of using image processing techniques in crack detection is the reliable results compared to manual methods. Due to holes, anomalies and vibrations, there are many issues in image-based detection. For crack detection, the processing complexity depends on the object size.

There are three common ways of detecting cracks in concrete structures that are structural expert Object inspection, automated approaches to image enhancement and automatic approaches to image processing and analysis[1].Different approaches are used to detect crack in concrete sructures,includeing transform method, approaches to graph theory, fractal geometry analysis, approaches to object correlation, percolation models, morphological operators,skeletonization techniques, centroid methods, approaches to texture analysis and edge detectors,etc

In this paper, a literature review is directed to identify the research challenges and the achievements of crack detection. The next section of the paper will deal about the literature survey. The paper will also discuss the analysis of the image processing techniques for the crack detection. This paper will also discuss the research gaps based on the literature survey. Finally, the paper will provide the conclusion of the study.

Literature Review

In 2009, Y. Sunet al [28], proposed an image processing based strategy for the pavement images. The strategy adopted by the author is speedy and self-versatile. The algorithm was tested on binary images after certain level of preprocessing of the images. The preprocessing was carried out to tackle the non-uniform lighting, noise and undesired features. Gaussian Spatial filter [12],[13] technique was used by author as it avoids a bright ringing effect of an image. Thresholding was used to obtain binary images. Morphological operations were carried out using dilation and erosion to remove the remaining noise. Authors did the

connectivity analysis of the crack pixel based on a depth-first searching method. The length and width of the crack was not considered by the proposed work.

In 2013,Mostafa et al[14], proposed automatic crack detection analysis and mapping. Its divided into three parts, 1) shading correction2) crack detection and3)mapping part. Shading correction part means preprocessing based on median filter. It is related to image processing, by mainly important the crack pixel and remove the background values.The second part is based on Probabilistic relaxation to prevent noise generation. At that point, an improved locally versatile thresholding was performed to distinguish crack precisely. The crack detection was defined in pixel coordinate. We converted pixel coordinate system to the global coordinate system because of crack detect should be redrawn.

In 2008 ,Siwaporn at al[24], applied image processing techniques on asphalt surface images. The techniques were applied to determine cracks from the asphalt surface.Huang and Xu[5], presented a novel approach known as Grid Cell Analysis on pavement images. According to their technique image was divided into grid cells of specific dimensions and classified as binary classes i.e cracked or not-cracked based on the gray scale information of the edge pixels. There were three main steps in Grid Cell Analysis :

- Preprocessing : This step was responsible for correction of original images by applying several parameters.
- Grid Cell Analysis Chain : It dealt with image shadow and shading problems. It also reduced number of conditions to tackle overlapping areas of an image.
- Cracked Cell Verification : It performed the verification of an image based on certain preassumptions.

In 2013,M.salman at al[15],proposed Gabor filter algorithm for pavement crack detection. Textures analysis and segmentation,[2][20][26]alphabet recognition, edges detection[11], object recognition illustration of images ,handwritten digits etc. Vision based application used by Gabor filter techniques. The Gabor Kernels are band pass filters and are oversee by the fundamental origination of vision data handling by different direct filtration in the mammalian visual structure.Applying the proposed algorithm 95% precision has been achieved on pavement images. Crack detection could be a feasible substitute to conventional crack detection by Gabor based techniques.

In 2012, Qin Zou et al[21], for automatic crack detection develop new global method crack-tree. Sometime pavement images have cast shadows of trees, light poles, etc., along the road.Thisalgorithmisto remove such shadows for more accurate results of crack detection. Pavement images are mostly ingrayimage. in this paper, we center our calculation advancement around monochromatic asphalt image. In the accompanying, we first present a surface adjusted IL luminance remuneration model to accomplish indeed, even enlightenment in shadowed asphalt images and afterward present the proposed geodesic shadow-expulsion algorithm. Then, construct a crack probability map using tensor voting (Medioni et al., 2000) on detected noisy crack pixels and crack fragment after removing the shadows. In this paper author use some selected parameters like voting scale ,edge length, path length and number of geodesic levels.

In 2015,Arvydas et al [4], introduce Digital Image Correlation (DIC) technique. This technique is use for crack localization. The image processing is an execute in two steps. To begin with, the image is adjusted to realize strictly horizontal position for the reason of expelling impact of view point and shape deformation. Encompassing commotion is also reduced. Along these lines, the vertical shape of splits is utilized in arrange to localize their position. Then next step is The Agglomerative hierarchical Clustering Procedure is utilized for recognizing the cracking pixels that closely take after one another.

In 2017, Jung et al [7], proposed image processing technique who identifying surface defects for pressed panel products. This technique follows the three steps. First step is object extraction from backgrounds, second step is object's shape and edge line extraction, and last step is edge line analysis for crack detection. Crack detection procedure have four steps based on image processing 1.Panel image acquisition 2.Object extraction from backgrounds 3.Object edge line extraction and 4.Crack detection and localization. Through examinations, it was indicated that the proposed image handling system had the option to distinguish surface breaks with the sensible precision and the speed. The proposed image handling system could be effectively utilized for break recognition in the squeezed board with the points of interest of cost decrease, quick assessment and high precision.

In 2018,Hong et al [18],in this paper introduce several edge detection techniques of image processing. The work was carried out for detecting cracks on concrete wall surfaces in an automatic manner. For edge detection the Roberts, Prewitt,Sobel and canny algorithms are used and methods for release the crack textures appearing in concrete wall.Median filter is a successful way to deal with smooth the digital image and reduce the unwanted noise in wall background. Roberts technique is a straightforward and quick calculation for ascertaining the spatial gradient estimation on a digital image and this calculation rapidly uncovers areas including high spatial recurrence which regularly compare to crack objects. To execute the Roberts strategy, the image is first changed over from the RGB group into the gray scale format. Subsequent to being handled by this calculation, pixel esteems at every area of the yield image are the approximated outright extent of the spatial slope of the first dim scale image at the area.

Analysis of an image processing techniques

Here discusses the work of following image processing techniques.

Morphological

Morphological image preparing is an assortment of non-direct tasks identified with the shape or morphology of highlights in an image. Numerical morphology is an incredible asset to extricate data from images that focuses on the geometrical structure

with in the image. The greater part of the morphological tasks like opening and shutting are jactualized utilizing the two fundamental activities, disintegration and expansion [27][19]. Numerical morphology gives a wide scope of administrators which depend on the idea of set theory [27]

Main morphological operations are Dilation and Erosiononbinary images [27].Dilation and Erosion are the primary capacities which make the item littler and bigger. Dilation expands the region of an article by including pixels around the limits and fills inside openings. Erosion makes an article littler by evacuating or dissolving endlessly the pixels on its edges. To complete the widening furthermore, disintegration two bits of information to be presented: an image to be dissolved or expanded, and the organizing component.

- Some basic Morphological Algorithms like: Boundary Extraction, Region Filling, Thinning, Thickening[27],Skeletons,ConvexHull,Extraction of Connected Components.
- Some application of morphology approach: Morphological smoothing Morphological gradient Top-hat transformation Textural segmentation,Granulometry.

Gabor Filter

Gabor filter is a straight filter utilized for surface investigation. It essentially dissects whether there is a particular frequency content in the image in specific directions in a limited district around the point or region of investigation. Recurrence and direction portrayals of Gabor filter are asserted by numerous contemporary vision researchers to be like those of the human visual framework. They have been seen as especially fitting for texture representation and discrimination.[16][25]

A Gabor filter is a combination of a Gaussian filter and a sinusoidal term.[25][11] The Gaussian gives the loads and the sinusoidal gives the directionality. A lot of Gabor filter with various frequencies and directions might be useful for removing helpful features from an image. Gabor features need to perform multi-goals deterioration because of its restriction both in spatial and spatial recurrence area [20][11].

Gabor filter technique is used in many application like : Fractal dimension management, Texture segmentation ,Retina identification, Edge detection, Image coding [25]

Median Filter

Median filtering is very widely used in digital image processing .The median filter is nonlinear type of filter. It is very useful for removing impulse noise, the “pepper and salt” noise, in an image processing [6].Noise reduction is a vital cleaning step which improves the outcome of the image after certain level of processing. The goal of the median filter is to replace the gray level of each pixel [22].

Some methods of median filter like: Adaptive Median Filter(AMF), Tristate- Median Filter(TMF), Progressive Switching Median Filter (PSMF), Two Stage Iterative Median Filter, Two Phase Median Filter, Vector Directional Filter, Threshold Median Filter[6][22].

Otsu Method

Otsu's technique Otsu's, named after its inventor Nobuyuki Otsu, is one of numerous binarization algorithms [10]. Otsu’s technique is changing over a dark scale image to monochrome is a typical image handling task. Otsu's thresholding strategy includes repeating through all the conceivable edge esteems and figuring a proportion of spread for the pixel levels each side of the limit [17].

Otsu's method is conveyed by a few image preparing applications to execute histogram based imagethresholdingor to change a gray level image to a binary image. The calculation presumes that the image grasps bi-modular histogram and further assesses the ideal edge, parceling previously mentioned couple of classes so their intra-class spread is irrelevant. The augmentation of the fundamental strategy to staggered thresholdingis named as Multi Otsu method[10].

Thresholding

Thresholding is an important technique of image segmentation. It is very simple and efficient one. Thresholding technique produces parallel image from a gray scale image. Segmentation gives the binary image as an output using concealing process. Segmentation generates number of binary images based on the pixel structure of an image. In image planning, thresholding is used to section an image into tinier segments, or tosses out, using in any occasion one concealing or gray scale a motivation to portray their point of confinement. The upside of getting beginning a parallel image is that it diminishes the multifaceted nature of the data and streamlines the technique procedure recognition and classification [23][8].

There are three types of thresholding algorithms.1) Global thresholding,2) Local thresholding,3) Adaptive thresholding [23][8]

Global thresholding: When the intensity distribution of objects and background pixels are sufficiently distinct the global threshold is used. In the global threshold, a single threshold value is used in the whole image. There are many global thresholding techniques such as: Otsu, optimal thresholding, histogram analysis, iterative thresholding, maximum correlation thresholding, clustering, and Multispectraland multithresholding[23].

Local thresholding: These techniques estimate a different threshold for each pixel according to the grayscale information of the neighboring pixels.Localthresholding techniques are region size dependant, individual image characteristics, and time consuming.[23].

Adaptive thresholding: Adaptivethresholding is where the edge esteem is determined for littler districts and along these lines, there will be distinctive edge esteems for various locales. This technique that removes background by using local mean and standard deviation[23].

Research Gap and Challenges

Based on the literature survey, we identified several research gaps and challenges. They are as under:

- The proliferation path of the crack: It is observed from the literature that it is crucial to detect the proliferation path of the crack. Longitudinal direction and traversal direction both are very important in the research of the crack direction.
- Prediction of the depth of open surface crack: No perfect algorithm is available in literature to address this issue.
- Realistic analysis of crack images: Form literature survey, it is identified that majority of algorithms work well with high resolution images and images with appropriate light conditions. No algorithm is available which does the analysis of crack images based on real situation.
- Fast analysis of risk of crack: Analysis of the risk of crack based on images is crucial for real environment. No such kind of decision making tool exists in the literature.

Conclusion

This paper provides the literature survey of the different image processing techniques used for the recognition of the concrete surface cracks. The main intent of this research was about to study and review the crack detection research work based on image processing. Based on the literature survey, the paper identifies several well-known image processing techniques and studies them in order to identify applications, advantages and limitations. Finally, paper deals with the research gaps and challenges in context to image processing for the crack detection. The research gaps and challenges noted by the paper are very important for the researchers who want to do the further research in this field.

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