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An Efficient Detection and Segmentation of Pavement Cracks in Remote Sensing Images using Grow Cut Algorithm

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***Abstract*- Pavement cracking detection and measurement is essential for maintaining a well thoroughfare network. Several algorithms are developed quickly in recent years to detection pavement disasters. Segmentation plays an important role in automated pavement crack detection method. In this proposed work, a binary image has been extracted from gray scale image using auto-tuned threshold value acquired from the Image Euler numbers to identify crack regions. Further, the enhanced image acquired by the auto tuned threshold process is run through with the Grow cut algorithm to get exact crack region. Image quality measurement is imperative for various image processing applications. Assessment of Image quality is intimately related to image similarity appraisal in which quality is based on the dissimilarity between an original image and distorted image. Eminent image quality measure algorithm includes Mean Squared Error (MSE), Peak Signal-to-Noise Ratio (PSNR), Normalized Absolute Error (NAE), Normalized Cross-Correlation (NCC), Feature Similarity Index (FSIM) has been assessed between original image and segmented image. The experimental shows that this method is efficient for segmenting pavement crack region from satellite imagery.**

Keywords- Pavement, Growcut algorithm, Image quality measure, crack region

I. INTRODUCTION

Segmentation is the process of obtaining significant region from images that are uniform with respect to image feature such as texture, color, edges etc. A wide range of computational vision algorithms can also benefit from existence of reliable and efficient image segmentation technique. There are several advance methods are available in image segmentation such as region-based methods, watershed methods and active contour methods, edge – based method. In this proposed work image segmentation involves minimal user interaction to put in user intention into the segmentation method and is a dynamic research area in recent years because it can attain satisfactory segmentation results.

The initial process is implemented with Euler minmax operation to extract a binary image from gray scale image using auto-tuned threshold value obtained from the correlation of Image Euler numbers in this the user can detect the object and background regions in the image. Based on auto tune threshold value the crack region gets detected. Now the Grow cut algorithm can be implemented to segment crack region from image. In this method, the number of labels and the class boundaries are identified based on local image features present in an image. Starting from arbitrary number of labels, each cell value gets updated using the information of its existing state and its neighbors. The grow-cut algorithm is interactive and robust segmentation. Cellular automata are difficult type adaptive system in which, minute close by operating units act in unity to produce a global evolving behavior.

The remainder of this paper is organized as follows. Section II introduces problem formulation and describes the preprocessing method. Section III explain about Grow cut algorithm. Section IV represents performance quality measure. Result and discussion in Section V. Conclusion and future work comprise in Section VI.

II. METHODOLOGY

In generally, the proposed method is too mainly to improve the competence and accuracy of pavement image distresses detection. This method is to detect and to segment the crack region like distress observed on the surface of a pavement region and the performance of the pavement is measured with respect to image quality measure. It consists of the following steps: (1) Assessment of Image quality based on the dissimilarity between an original

image and segmented image, (2) auto tuned threshold value for detecting crack region, (3) Grow cut algorithm has been proposed to segment exact crack region. Figure 1 expressed the architecture of the proposed method.

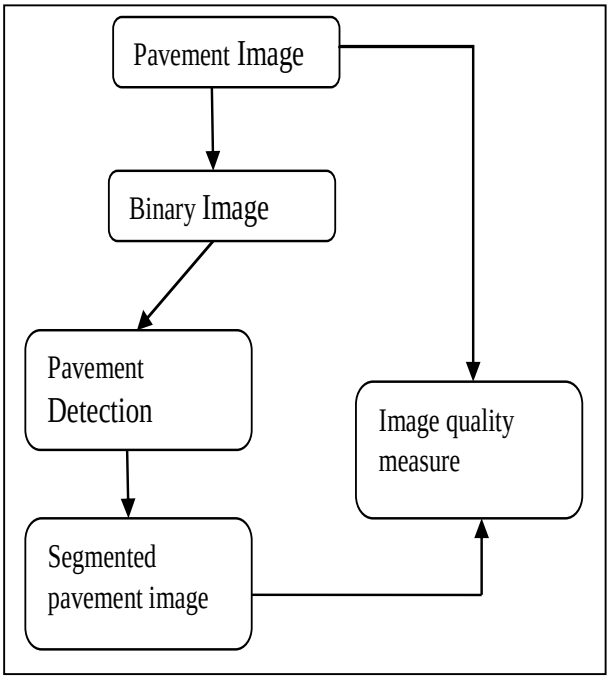


Figure 1. System Architecture

III. GROWCUT ALGORITHM

Grow Cut is an interactive and robust segmentation algorithm. It makes use of cellular automaton as an image depiction. Automata evolution model represent segmentation method. In this proposed work Grow cut algorithm has been taken for segmenting the pavement crack region. For this Grow cut algorithm is incorporated with Cellular automata based framework using low-level image features such as color pixel intensity values. The operation is very simple; which is to view each image pixel in an image as a cell type. Each cell of the automata has a number of labels. Various cells confine their neighbor, alternate with their labels at automata progress. Cellular automata are dynamic systems that progress on a distinct grid of cells that interact locally to generate information at a global level. Usually, a CA consists of some pre-defined state-transition rules to decide the value of each cell based on the value of its neighborhood cells. In case of image segmentation, the state transition rules are in functional to update the value of each pixel in an image. A cellular automaton is definite using a triple(S,N,δ), where S is the state, N is the neighborhood and δ is the state transition function (rule). In the case of image segmentation, S is the class-label associated with a pixel. The neighborhood (N) of a pixel p is defined on R2 as.

$$N=B(p; r) \cap Z \quad (1)$$

Where B (p;r) is a center circle at pixel p with radius $r \geq 1$[3].

The initial labels and the number of labeled points are resulting arbitrarily from the space of positive integer values. The state of each cell is given by a 3-tuple (l, θ, I), where l is the label, $\theta \in [0, 1]$ is the potency of the cell and I is the pixel intensity. The potency of a cell is to depict the state transition function for updating the labels of cells at each time step. Initial arbitrary pixels are labels are assigned with cell potency 1. The state transition rule between two pixels p and q is defined using a monotonically decreasing function g as

$$g(|IP- Iq|).\theta q>t \quad (2)$$

Where

$$g(x) =1- (\frac{x}{\max|I|}) \quad (3)$$

The threshold parameter t, determines the quantization of pixel intensity values which is assigned manually. The process gets iterated until the local label stops occurring. In this proposed method, the number of labels and the class boundaries are identified based on auto tuned threshold value which is used for detecting the pavement crack regions. Starting from arbitrary number of labels, each cell value gets updated using the information of its existing state and its neighbors based on this pavement crack region get segmentation.

IV. IMAGE QUALITY MEASURE

Image Quality Measurement (IQM) is imperative in the progress of image processing algorithms such as enhancement; deblurring, denoising etc. It is used to evaluate the performances in terms of quality of processed image.

A. Mean Square Error (MSE)

Mean Square Error measures the average of the square of the "error". The error is the amount by which the estimator varies from the quantity to be estimated. The difference occurs because of arbitrariness or because the estimator doesn't account for information that could produce a more accurate estimate [11].

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} | [x(i,j) - \hat{x}(i,j) |^2 \quad (4)$$

B. Peak Signal-To-Noise Ratio (PSNR)

PSNR is an engineering term for the ratio between the utmost possible power of a signal and the power of corrupting noise that affects the reliability of its representation. PSNR is the evaluation average of the reconstruct image quality, and is essential feature. In this 255 is maximum possible value that can be acquired by the image signal which is infinite [11].

$$PSNR = 10log\left(\frac{255}{\sqrt{MSE}}\right) \quad (5)$$

C. Normalized Absolute Error (Nae)

Normalization is the method of dividing statistical error in frequent calculated data. It is based on a property. In statistics, normalization refer to splitting up of various sets of data by a common variable in order to cancel out that variable's consequence on the data, thus original characteristics of the data sets to be compared: this permit data on different scales to be compared, to bring them to a common scale. In measurement level, these ratios only make use for ratio measurements

$$NAE = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}|x(i.j)-\hat{x}(i,j)|}{\sum_{i=1}^{M}\sum_{j=1}^{N}|x(i.j)|} \quad (6)$$

D. Normalized Cross-Correlation (Ncc)

Normalized Cross-Correlation is the methods used for pattern matching, which is used for finding incidences of a pattern or object within an image.

$$NCC = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}(x(i,j)-\hat{x}(i,j))^2}{\sum_{i=1}^{M}\sum_{j=1}^{N}x(i,j)^2} \quad (7)$$

E. Feature Similarity Index (Fsim)

The well-known structural-similarity (SSIM) index brings Image quality assessment from Pixel-based stage to structure-based stage. From high phase congruency (PC) the highly informative features can get extract. Phase congruency is used as the prime feature for calculating FSIM [13]

$$\mathrm{FSIM} = \frac{\sum_{x\subset\Omega} S_L(x).PC_m(x)}{\sum_{x\subset\Omega} PC_m(x)} \quad (8)$$

F. Structural Content (Sc)

The loss in apparent image quality is frequently determined by the nature and artifact level along with the framework in which it becomes visible.

$$\mathrm{SC} = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}|x(i,j)|^2}{\sum_{i=1}^{M}\sum_{j=1}^{N}\hat{x}(i.j)^2} \quad (9)$$

Results,

This proposed method has been tested on various images. Euler MinMax operation is used to extract a binary image from gray scale image to detect the pavement crack region in the image which is then sprint with Grow cut algorithm to carry on expanding and merging of the labels by means of an equality relation to get final figure of class labels. Now the pavement crack region gets segmented. Image quality measure has been calculated for original image and segmented image and it is tabulated below and the graphical representation has been depicted. This work has been implemented in Matlab. Each image gets various performance measure values which are not compared with another image. With these two images various image qualities has been obtained. The experimental

result is shown below. Table1 represents the Performance Measure and Figure2 represents the Graphical Representation for Image Quality Measure.

TABLE 1. PERFORMANCE MEASURE

Image	Peak signal-to-noise ratio	Mean square error	Normalized cross-correlation	Normalized absolute error	Feature similarity index	Structural Content
Input Image(a1)	10.7599	5.458	1.3457	0.3791	0.4696	0.5399
Input Image(b1)	7.2310	1.230	1.7425	0.8027	0.6435	0.3187

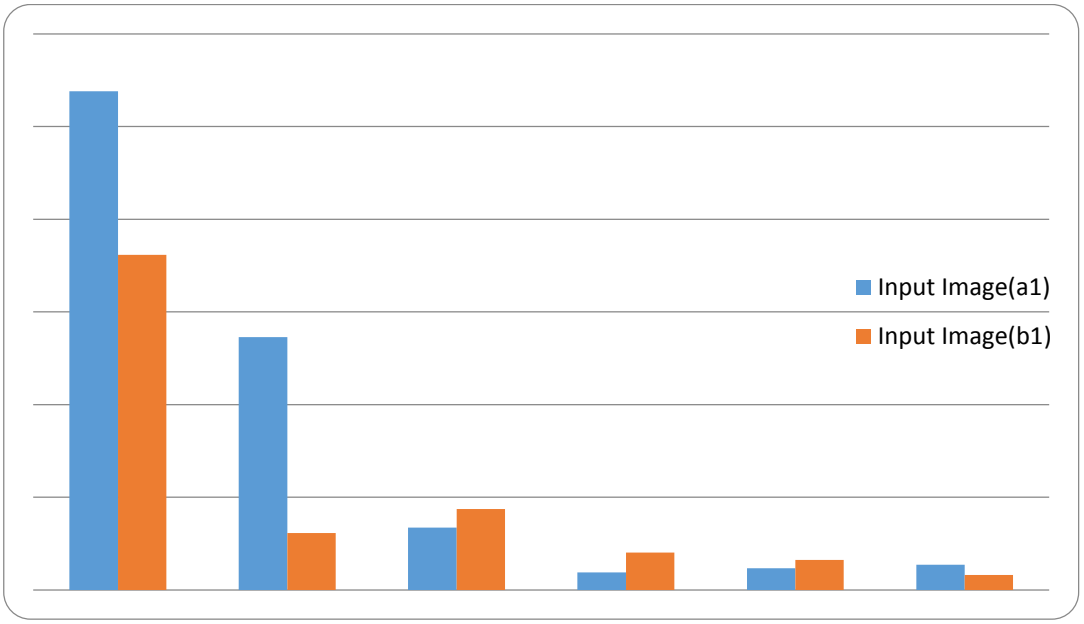
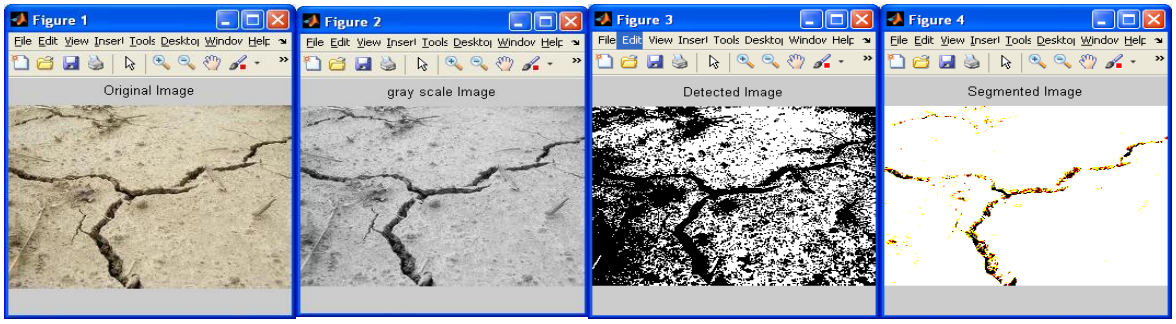
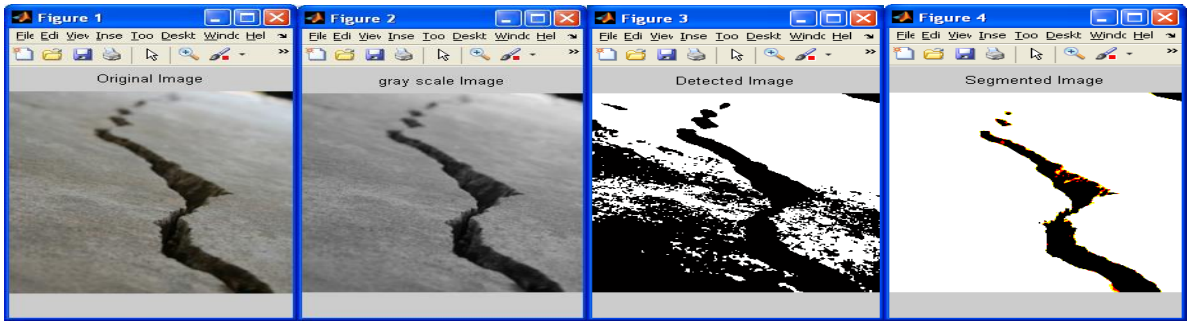


Figure.2 Graphical Representation For Image Quality Measure



(a1) Input Image (a2) Gray Scale Image (a3) Detected Image (a4) Pavement Segmentation



(b1) Input Image (b2) Gray Scale Image (b3) Detected Image (b4) Pavement segmentation

V. CONCLUSION

In this proposed method, pavement crack region has been segmented based on Grow cut algorithm. Based on initial Euler minmax operation the crack region can be detected from binary image. A cellular automaton is incorporated with Grow cut algorithm it shows that capable parallel execution is probable. The class labels are regularly resolute by algorithm at run case. Proposed method combines the advantages, high speed enough for segmentation and present algorithm extensibility for other feature, more interactivity for segmentation process. The experimental results show that the proposed approach has a better robustness and exactness for segmenting pavement crack region.

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