A STUDY OF ROAD CRACK DETECTION BY IMAGE PROCESSING

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ABSTRACT

This trial describes the detection of road cracks from images of road surfaces using image processing. The detection capability of the road cracks was studied on the basis of appropriate image processing steps but without considering real time execution or application. Our aim is to obtain some quantitative tendencies related to human observation in two dimension monochrome images. The overall procedure steps were as follows: a "Morphology" filter was applied in the pre-processing of the original image, "Template Matching" controlled by "Genetic Algorithm" was then applied as the main processing, and mismatched areas were then adjusted in post-processing. As a result, using a limited number of image data, the appropriate cracks to be visible by human observation of the images were detected by this method.

1. INTRODUCTION

Currently, an automatic detecting scheme with analytical study has been reported in preferable output results on subject to ground depression of car wheels. The road crack detection, however, is still under consideration about cost and/or time problems since it employs laser-beam detecting apparatus to find cracks in the variety of road surfaces. While an ultra-red detecting system is available to check the temperature distribution of the air gap at the wall in concrete buildings, but not applicable to road cracking yet since the road surfaces may not expose enough to find cracks together with their specific temperature differences. Then detecting capability of the road cracks has been studied on the basis of appropriate image processing steps but without considering real time execution or application. Our aim is to obtain some quantitative tendencies related to human observation in two dimension monochrome images.

The input images which were offered by Komatsu Engineering Co. has been used in this experiment; the size of 512x512[pixels] depth of 256 gray levels, and the resolution of roughly 2 to 6[mm] of cracking width. The detected results by human observation were also utilized for comparative evaluations.

2. ROAD CRACS

Current report describes about the road cracks as;

- a variety of crack widths and/or crack directions are widely distributed, and
- a variety of partial cracks or disconnected cracks are randomly distributed.

While gray level variations are highly existed as noise due to the materials of rocks. It is also said for acquisition data to be compressed enough to extract necessary road cracks. The road surfaces have variety of texture patterns due to the structure material of concrete or asphalt. They are not always identical in reflecting responses at the input stage between smoothness of road surface and smoothness of gray level image. Because variety of reflections into camera might be received from their individual materials of

rocks. While road cracks might be distinguished in a sense of connected dark spots from other places of backgrounds. Some of the assumptions in this trial are set as;

- road cracks are connected in series of dark spots,
- white or yellow traffic indications are not considered, and
- artificially created materials, man-holes, construction plates, etc. are not considered.

There might be a tendency on detecting dark spots to be a part of long ranged cracks even though they look individually. While the background, in general, does not show the certain regularity in their connectivity which might be a key to distinguish from actual cracks, and be a necessary condition but not a sufficient condition.

3. PREPROCESSING OF IMAGE DATA

Additional data conversion are needed to help more detecting capability. A human observation expects that the road surface must be smooth enough for the undetected area against dark spots of cracks. Here we have employed simple but flexible filter over the randomly distributed or leveled input data, and morphology operation considered to be a non-linear filter is applied to them. In theoretical view point, the absolute gray levels are not important but the relative gray levels to the road surface are rather important to apply morphological operation over the un-flattened surface of the road. In this trial, we have examined to apply this operation to reduce the roughness of the road, which would be handed to main processing.

4. TEMPLATE MATCHING

Here template matching(hereafter TM) to search specific road cracks has been studied. The template which looks V-shaped groove in rectangular block image must be scanned over the preprocessed image plane. The similarity must be measured quantitatively in each scanning position between input image and template. Generally, TM is considered to be unsuitable to the size variations or rotations of target image. It is necessary to consider the following items for template as; the shape = {square, rectangle, circle, etc.}, the size = {3*3, 3*5, 5*5, etc}, and the groove = {single, double, crossing, etc.}, the bottom of groove = {box-shaped, U-shaped, V-shaped, etc.}, and the crook of curve as well. It is not definite of detecting ability in cracks with fixed template, since the condition of road cracks varies so widely and randomly. In this experiment, we have employed one of rectangular shaped groove as a template. The following equation has been utilized to obtain quantitative measure as:

$$\text{SIMILARITY} \equiv \Sigma i \Sigma j \mid Fij - Tij \mid , \quad (i=1\text{-}m, j=1\text{-}n) \qquad (1)$$

where, $\mid . \mid$ indicates an absolute value, F and T mean input image and template, respectively, and m and n mean the size of template in horizontal and vertical, respectively. Here input images are normalized from 0 to 1, and the better the similarity the lower the value in eq.(1). Due to the assumption to the cracking in the previous section, "connected groove" is said to be different from "large concaved area". In this view point, there might be some intuitive and distinctive detection using TM, and the similarity in Eq.(1) using TM of both vertical groove and horizontal groove were checked. That is, the area of aspect ratio in between two TMs may suggest to help distinction of cracks from non-cracks. It will be needed to prepare the number of templates to increase their matching reliability in detecting process.

5. SCANNING OF CRACKS

In general, the road cracks occupies less area than that of background. This is the feature of cracks for having adjacent connections to each

other with occupied area of rather small. In scanning sequence on image plane by template from upper-left to lower-right has not been taken in this experiment. Because we want to skip meaningless areas of scanning and for the scanning order to be depending on their similarity values. At least, the system must judge whether cracks are existed or not according to the similarity measure in Eq.(1). It will be desirable not to be diverged but to be converged in scanning directions closer to the area of target groove. So that GA is considered to be useful for the purpose of paying attention to the candidates of optimal solution in image plane. The GA tries to run its procedure according to probabilistic measure based on the value of evaluation function. In addition, the further scanning might be neglected when the evaluation value become better enough to the target level.

6. EXPERIMENTS

In this experiment, two dimensional image data and their evaluations of human observation are offered by Komatsu Engineering. Some original input data are shown in Fig.1(a)-(c). They are classified into two categories to detect cracks by human as; (a) rather difficult, (b) and (c) difficult. The problem is how to define the common tendency of cracks in variety of circumstances to the two dimensional distribution. Figure 2 is the result of applying and so-called "Regional-Max" of Fig.1(a). The smoother surfaces can be seen in this figure, which is used to be rough at the input stage. The template size, and the parameter values as well must be related and depend on the degree of image resolution at the input stage. Here this resolution was fixed to be unchanged, and two sizes of template have been used; large(41*41) and small(21*21). Also, the template of 90 degrees rotated was prepared in order to catch the cracks of rotated directions. Figure 3 is shown as a computational feature space according to Eq.(1) on the image of Fig.1(a). Figures 4(a)-(c) are shown as the results of this algorithm, where, (a)-(c) are subject to the original images of Fig.1(a)-(c), respectively. The small squared marks show the detected points by this system as cracks in these figures and some errors in large and dark areas though there are limited number of samples. It shows a reasonable detection in images considered to be "rather difficult", however, there are some incorrect detection in image of considered to be "difficult". There might be a certain relation between human observation and our procedure in crack detection.

7. CONCLUSION AND DISCUSSION

A study of road crack detection by image processing has been described. The overall procedure steps are as follows; the morphology filter was applied for pre-processing, TM based on GA detection was then applied for main-processing, and mismatched areas were adjusted by using line fitting procedures. The proposed algorithm has a certain meaning in generalized processing steps unlikely to the rigid and problem-oriented algorithm. This leads us to some other applications such as extracting blood tubes with adjusting system parameters. The merits of this system are; the possibility of replaced hardware architecture, the detecting capability is likely to eye observation, and partial processing of the frame size 512*512[pixels], and so on. On the contrary, the demerits or feature study would be the reliability of its detection which must be effective for a variety of road cracks, the adaptability of template parameters, and rejecting scheme of {man-holes, traffic signs, artificial creatures}. Color information or temperature information of road surface might be another factor for helping its detecting capability. There is no guarantee for 100% recognition of road cracks from given two-dimensional gray level images. The detecting decision can be yielded {clearly, ambiguously, unknown} at site by human observation to make sure under the actual

circumstances.

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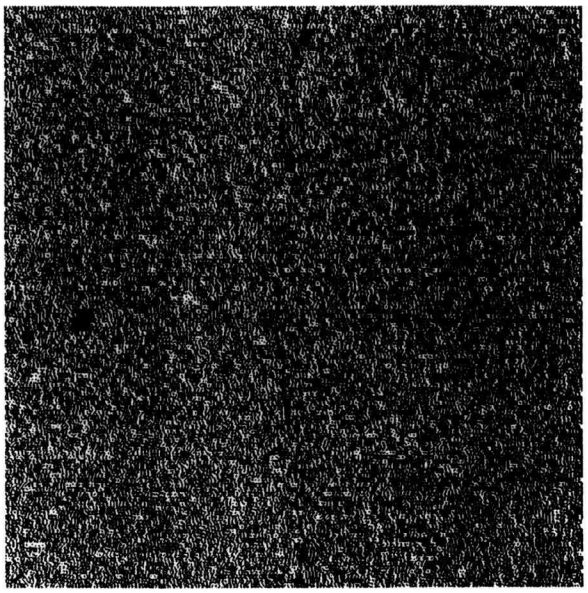
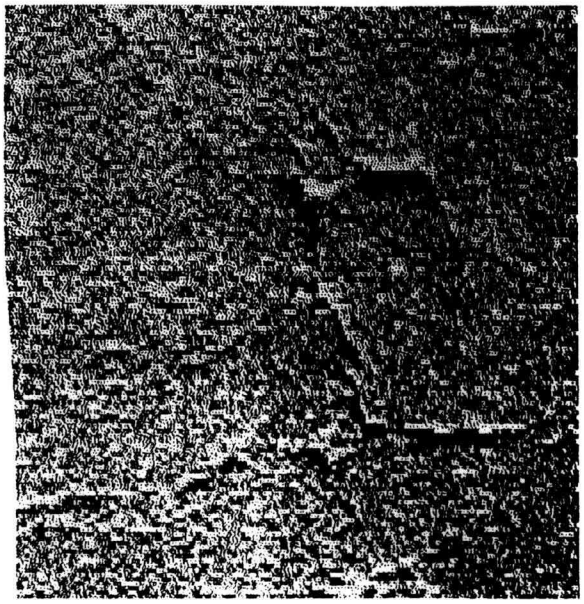


(a)



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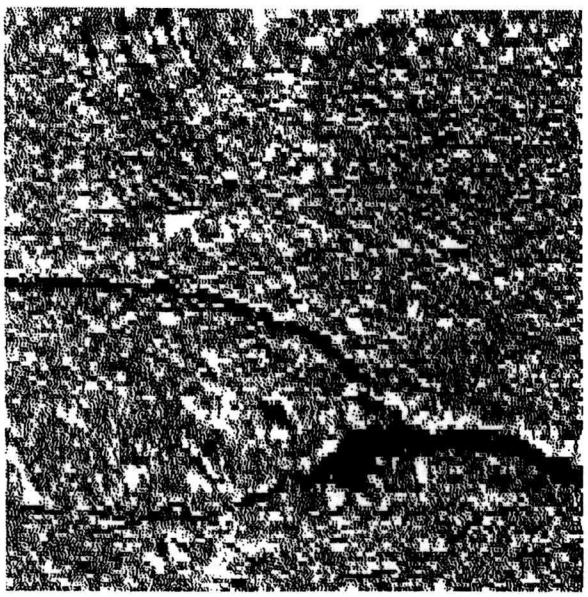

(c)

Fig.1 Original Images (a), (b), (c) 512x512 pixels(500x500mm)

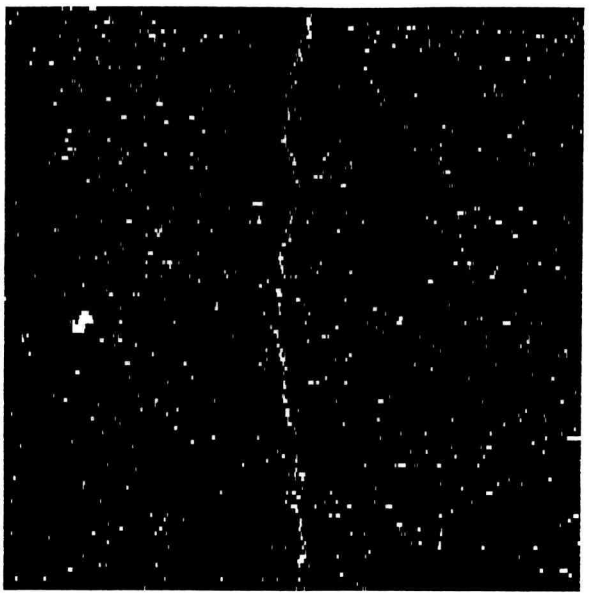

Fig.2 After Preprocessing

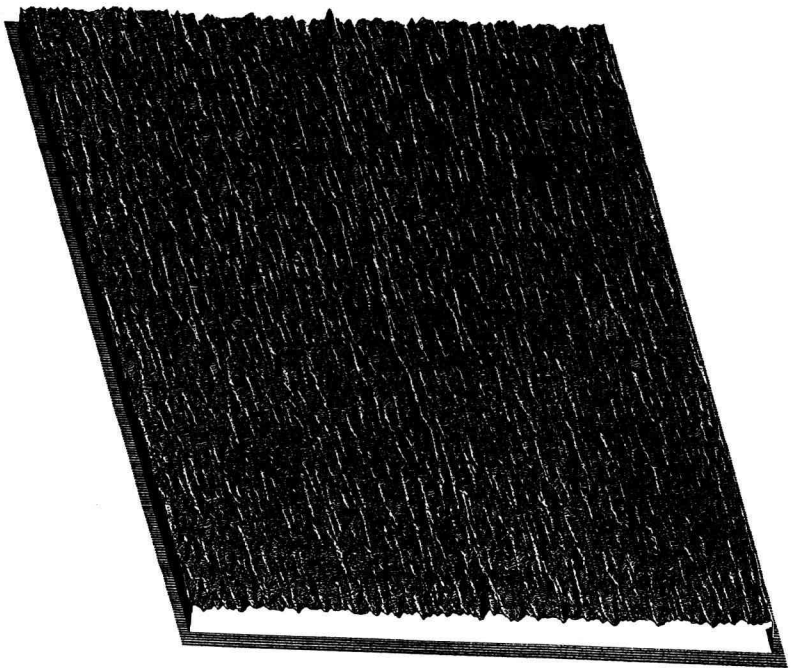

Fig.3 Feature Space Plane

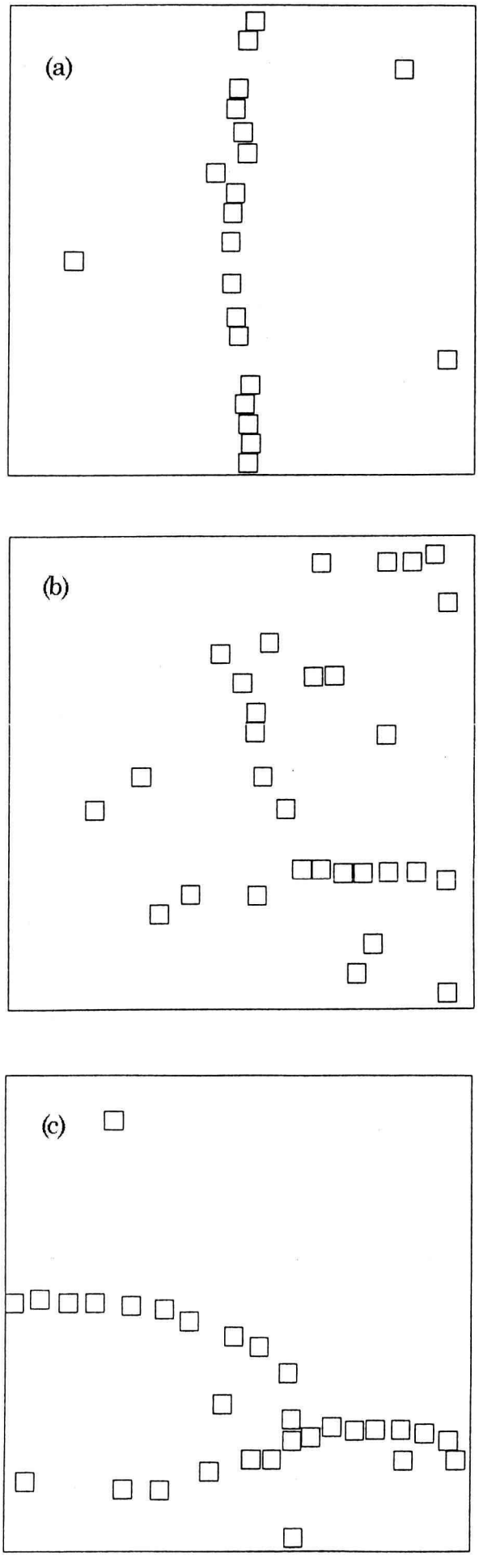

Fig.4 Results (a), (b), (c)