

Automatic extraction of pothole objects using image processing techniques

Tự động phân tách đối tượng hố trên mặt đường sử dụng các kỹ thuật xử lý ảnh

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Abstract

This study aims at developing an image processing based method for automatic extraction of pothole object on surface of asphalt pavement road. Image processing methods including Median Filter, Otsu's method for image thresholding, and image morphological analyses are employed for extracting pothole objects from digital images. Experimental results with image samples demonstrate the effectiveness of the developed image processing tool.

Keywords: Pothole extraction; image thresholding; image processing; asphalt pavement; defect detection.

Tóm tắt

Nghiên cứu này phát triển một phương pháp xử lý hình ảnh để trích xuất đối tượng hố trên bề mặt đường trải nhựa. Các phương pháp xử lý hình ảnh bao gồm bộ lọc trung vị, phương pháp Otsu cho phân ngưỡng ảnh và phân tích hình thái hình ảnh được sử dụng cho việc phân tách các đối tượng hố từ hình ảnh kỹ thuật số. Kết quả thử nghiệm với các mẫu ảnh đã cho thấy tính hiệu quả của công cụ xử lý hình ảnh được phát triển trong nghiên cứu này.

Từ khóa: Phân tách đối tượng hố; phân ngưỡng hình ảnh; xử lý hình ảnh; mặt đường nhựa; phát hiện khuyết tật.

1. Introduction

Roads are very important components of the transportation network. Thus, assessing their serviceability is a very crucial task during periodic surveys [1]. Needless to say, road degradation leads to an increasing number of traffic accidents and economic losses [2]. Hence, there is a practical need to enhance the

productivity of the current road maintenance process. In this study, we focus on a critical defect appearing on asphalt pavement road which is the pothole object. Generally, a pothole can be regarded as a bowl-shaped depression on the pavement surface with a minimum plane diameter of 150 mm [3]. To enhance the productivity of the current road

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maintenance process, we develop an automatic approach for extracting pothole objects from two-dimensional (2D) pavement images.

2. Image thresholding using Otsu’s method

Otsu’s method [4] is a simple yet effective image thresholding technique. This technique is based on the idea of separating the pixels within an image into two groups. The separated object is characterized by ω_0 and μ_0 which are the ratio of the number of pixels and the average gray level. Similarly, the background of the image is featured by ω_1 and μ_1 . Thus, the total mean of gray level of the image is defined as follows [4, 5]:

$$\mu = \omega_0(t)\mu_0(t) + \omega_1(t)\mu_1(t) \tag{1}$$

where t represents a gray level of the image.

The image is optimally thresholded if the following optimization function $f_s(t)$ is maximized [4, 5]:

$$Arg \ Max_t \ f_s(t) = \omega_0(t)(\mu_0(t) - \mu)^2 + \omega_1(t)(\mu_1(t) - \mu)^2 \tag{2}$$

3. Program Applications

The computer program used for automatic extracting pothole object in this study consists of six major steps:

- (i) Image enhancement using Median Filter
- (ii) Conversion of color image to gray-scale image
- (iii) Image thresholding using Otsu’s method
- (iv) Image enhancement using morphological analyses
- (v) Pothole object localization
- (vi) Pothole object extraction

It is noted that the computer program is developed with the Visual C# .NET framework 4.6.2. The first step of the program aims at pre-processing image samples to reduce image noises and remove redundant details [6]. The Median Filter is used in this step. After the image is converted to gray-scale one (see **Fig. 1**), the Otsu’s method is applied to separate the original image into the object of interest and the background (see **Fig. 2**). Morphological analyses are carried out to remove small objects and crack objects [5, 7-9]. The location of a pothole is identified by a rectangle surrounding a pothole object (see **Fig. 2**). Finally, the pothole object can be extracted via image convolution and cropping operations. The application of the developed program has been demonstrated in **Fig. 3**.

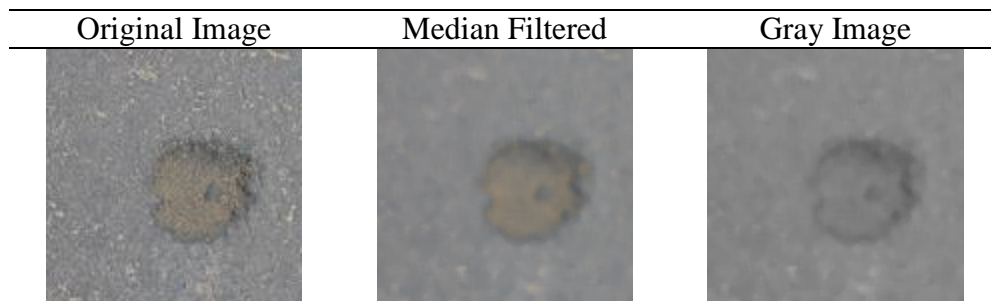


Fig. 1 Image Processed by Median Filtering

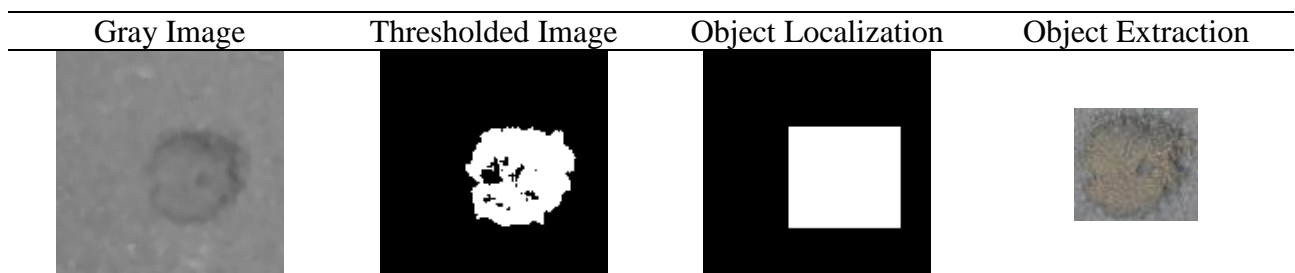


Fig. 2 Illustration of Object Extraction Process

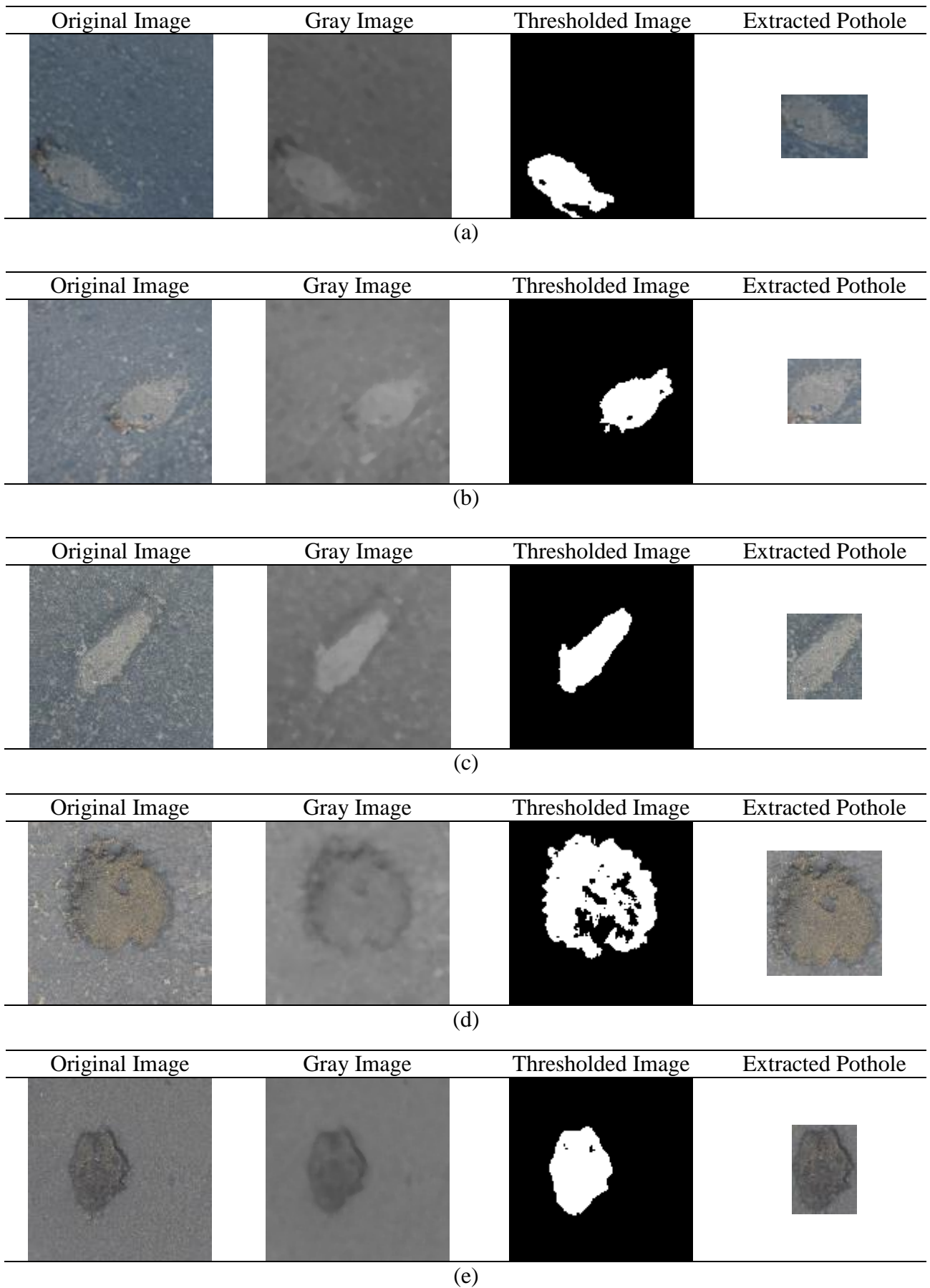


Fig. 3 Image Segmentation Results

4. Conclusion

This study has developed an image processing based method for automatic extraction of pothole object on surface of asphalt pavement road. Image processing methods including Median Filter, Otsu's method for image thresholding, and image morphological analyses are used for extracting pothole objects from digital images. The method has been developed with the Visual C# .NET framework 4.6.2. Experimental results with five image samples have confirmed the usefulness of the newly developed tool.

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