A Searching and Enhancement Alogorithm for Shadow Areas Using Histogram and Correlation in Fourier Domain

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Abstract: Searching and enhancement of shadow area in the satellite imagery is one of growing interest because of new possible needs of application in this field. This paper proposes an algorithm to search and enhance the shadow areas caused by buildings such as apartments which are very common in Korean satellite imagery. The proposed searching algorithm makes use of characteristics of histogram of images in the spatial domain and also uses the fast Fourier transform and correlation in Frequency domain. Further, the enhancement algorithm is only applied to the shadow areas searched and preserves the areas which are naturally dark.
Keywords: Satellite Imagery, Correlation, Shadow Area

1. Introduction

There has been considerable recent interest in searching and enhancement of shadow area of 1-m satellite imagery [1-2]. It is reported that the shadow area in the satellite imagery is useful to detect building images semi-automatically [3-4]. Sohn et al. reported a searching and enhancement algorithm for shadow area which can not be performed automatically [1-2]. K. L. Kim et al. reported some more complex method to search special areas which uses clustering, labeling, segmentation, feature extraction, and fuzzy theory [5]. K. L. Kim et al. also reported the feature extraction method which can be performed semi-automatically or automatically by comparing color images with grey-scale images [6]. However, no methods to search and enhance the shadow area semi-automatically or automatically are reported as far as authors know.

We present a searching and enhancement algorithm which can be performed semi-automatically or automatically. The searching algorithm uses the correlation to obtain the template to extract shadow area from a satellite imagery. The algorithm preserves the bright area (sunny area) because we perform the enhancement algorithm only for shadow area which is separated from the bright area.

2. Searching and Enhancement Algorithm

Enhancing the picture quality of the shadow area tends to degrade that of the bright area in the satellite imagery as shown Fig. 1, when we use the enhancement algorithms such as histogram equalization, histogram specification, or contrast stretching etc. which are proper to process dark area in images.

1) Extraction of Shadow Area

To prevent the degradation of picture quality in the bright area, we need to separate an image into two parts, sunny area and shadow area, to use the algorithms only in shadow area but to preserve the sunny area as it is.

Fig. 1. A 500x500 satellite image which includes shadow area.

Binarization algorithms based on the grey levels can lead to the problem of diffuse shadow areas as shown Fig. 2. We introduce the correlation to make a template which can be used to extract shadow area from the satellite image. Correlation $C(u,v)$ can be computed by solving

$$C(u,v) = \mathrm{Re}\{F(u,v) * G(u,v)\} \quad (1)$$

where $f(x,y)$ and $g(x,y)$ are two image signals and $F(u,v)$ and $G(u,v)$ are Fourier transformations. Actually, the correlation $C(u,v)$ can be computed by first rotating an image m by 180 degrees and then using the FFT-based convolution techniques as follows

$$C(u,v) = \mathrm{Re}[F^{-1}\{F(M)G^{p}(m)\}] \tag{2}$$

where F^{-1} means inverse Fourier transformation, and $F(M)$ denotes Fourier transformation of image M and G^{p} is Fourier transformation of an image m rotated by 180 degrees.

Fig. 2. After binarization by greylevel 128.

Fig. 3. A template for shadow area obtained by correlation of 8x8 shadow block and original image.

Using the template Fig. 3, the shadow area can be extracted as shown by Fig. 4. Likewise, the bright area can be extracted as shown by Fig. 5.

Fig. 4. Shadow area extracted from the original image.

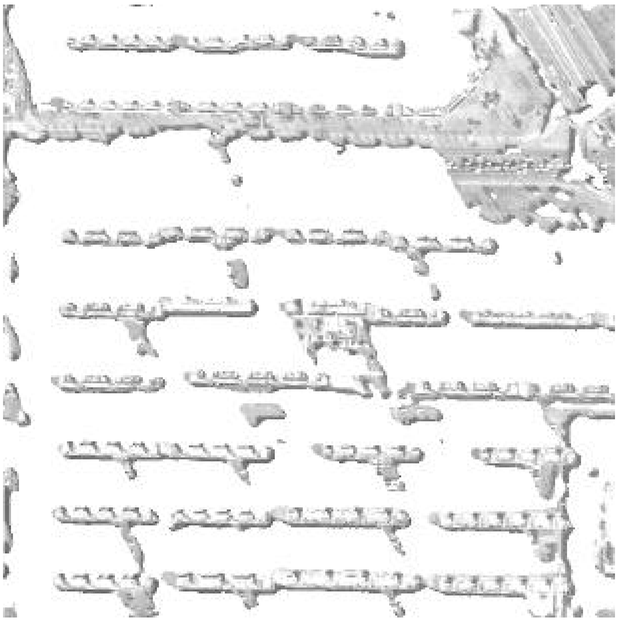

Fig. 5. Bright area extracted.

2) Enhancement of Picture Quality of Shadow Area

To enhance the picture quality of shadow area, histogram equalization is used. Fig. 6 shows the result.

Fig. 6. Shadow area after histogram equalizion.

4. Simulation Results

In the experiment, we used 8x8 block of shadow area to compute the correlation of the satellite imagery. Actually, we computed the correlation using Eq. 2 (refer [7]). The Fig. 3 is obtained using threshold 1,500,000 which is a little less than the maximum value 2,229,975.

The correlation provides the template for shadow areas which can extract the shadow areas from the original satellite imagery. The shadow area obtained by using the template does not have diffused point areas. The image quality of shadow area is improved by histogram equalization while the bright area is preserved as it is. After that process the shadow area and the bright area are added.

Fig. 7 is the resultant image obtained by histogram equalization for the original image Fig. 1. Fig. 8 shows the resultant image using the algorithm we suggested. After histogram equalization without our algorithm, the objective picture qualities of shadow area and bright area are degraded to 27.99 dB and 22.79 dB respectively in PSNRs(peak-signal-to-noise-ratio). Bright area degrades more than shadow area does. Considering that while the subjective picture quality of shadow area aggrades the degradation of bright area in the satellite imagery can be critical sometimes. Thus, the algorithm we propose is useful to improve the picture quality of shadow area preserving that of the bright area.

5. Conclusions

The correlation of a small block of shadow area and the satellite imagery provides the template which is not diffuse for shadow areas. Using the template, the shadow area and the bright area can be separated. While the conventional enhancement algorithms degrade the picture quality of bright area, our algorithm can enhance the picture quality of shadow area more effectively preserving that of bright area as it is.

Fig. 7. Reconstruced image.

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