Disparity determination using multilevel products

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ABSTRACT

We determined the overall disparity from stereo images using multiscale products of disparity values. Using the wavelet transform, we used a multiresolution analysis to calculate disparity values from stereo images at different scales. Forming the product of disparities and rescaling resulted in a disparity map that was directly related to depth. Using a multiresolution approach allowed us to more accurately determine disparity by examining the consistency of results through different scales. Using this approach could form the basis of an effective method for depth estimation.

Keywords: disparity, multiresolution image processing, stereo vision, wavelet transform

1. INTRODUCTION

Traditional stereo matching methods work reasonably well under ideal conditions. In other instances, such as low-contrast images, non-uniform illumination, or noisy images, disparity calculations may not be robust. Despite the advances made in the correspondence problem, a robust method is still needed for matching. A basic form for disparity calculations involve a block matching method. Such an approach finds disparities with neighborhood operations. Disparity at a point in one image is determined by comparing a small region about that point with a seris of regions extracted from the other image.

Traditional matching cost estimation includes, sum-of-squared differences (SSD), sum-of-absolute differences (SAD) and normalized cross-correlation (NCC), among others.[1,2] They behave in a similar way and are sometimes preferred over more advanced methods when considering real-time operation. Typically, the matching cost is performed over a square window or through Gaussian convolution. Improved performance may be achieved by combing the results of different sized windows such as shiftable, or size-adaptable windows.[3,4] The rank transform has been use to eliminate sensitivity to radiometric gain and bias. This approach computes cost with relative ordering of values within a window, and then block matching is performed using SSD or SAD. The problem of using the rank transform is that it reduces discriminatory power since image data is replaced with a ranking.

We also used a block matching approach, but used windows modulated by wavelets at different resolutions. In addition, we use the product of the results obtained with windows at different resolutions to determine disparity. Using a multiresolution approach allowed us to more accurately determine disparity by examining the consistency of results through different scales. Such an approach has been used successfully in edge detection.[5] In the next section, we briefly describe our approach, then described some experimental results.

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2. DISPARITY FROM MULTISCALE PRODUCTS

The goal of stereo image matching is often to determine the disparity map, which contains the depth information of a particular scene. Using two stereo images, the most popular setup is to have the images displaced in only the horizontal direction to reduce the computational requirement. Typically, an image chip is selected in one image and compared to same size regions in the other image at different horizontal displacements. The position where the match is best determines the disparity. A schematic diagram of the process is shown in Fig. 1.

Using the wavelet transform, an image *I(x,y)* may be decomposed into lower resolution approximation images at *j* different scales $A_{2^j} I$, at each scale where $-1 \le j \le -J; (n,m) \in Z^2$,

$$A_{2^j} I = I(x,y) \otimes \phi_{2^j}(-x,-y) . \tag{1}$$

We considered the product of disparities obtained at different scales. Considering $D_{2^{-1}}$ as the disparity map at the *j*th scale, the product across *k* scales can be written as,

$$P^k = \prod_{j=-1}^{-k} D_{2^j} . \tag{2}$$

Finally, the power of the product disparity was rescaled so that its energy was made equal to the energy of the average disparity such that,

$$\sum_{x,y} (P^k)^2 = \sum_{x,y} \sum_{j=-1}^{-k} (D_{2^j})^2 . \tag{3}$$

4. EXPERIMENTS

We a stereo image pair of a portion of damaged tile from the Space Shuttle in our experiments. The images were taken by a conventional digital camera, and the left image is shown in Fig. 2(a). This particular stereo pair pose a problem because of the lack of color and contrast in some areas. No attempt was made to further process the results to identify occluded or constant areas. Using the conventional SAD matching approach, the result in

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Fig. 2(b) was obtained. We generated a lower-resolution of the original image according to Eq. (1) and formed the product with disparities between that level and the original image. This result is shown in Fig. 2(c). Using two levels of the wavelet transform, the disparities resulted in the image in Fig. 2(d). Although sometimes difficult to see, using more levels seemed to improve the depth resolution of the result and provide more detail in Fig. 2.

4. CONCLUSION

Using multiscale products of disparities generated from windows from the wavelet transform seemed to improve the depth resolution of the result and provide more detail in disparity calculations. Using this approach may form an effective method for disparity calculations when compared to more conventional forms.

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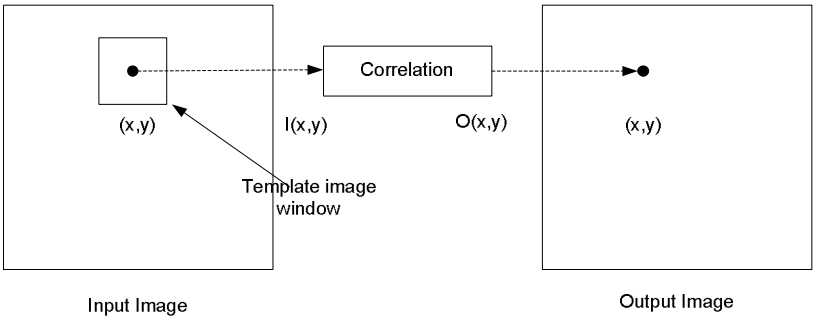
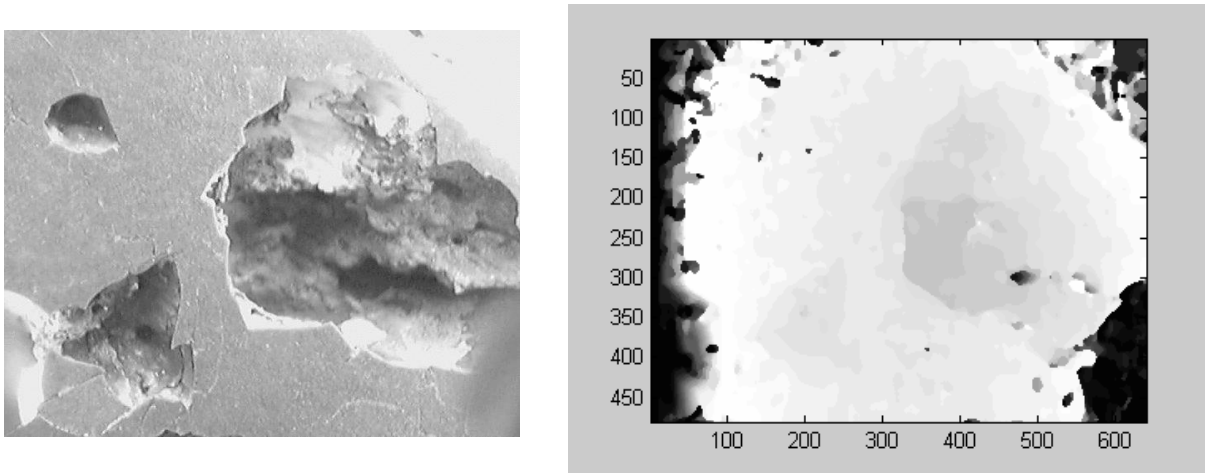


Figure 1 Schematic diagram of disparity calculation process.



(a) (b)

Figure 2 (a) Left Image used in experiments (b) result of conventional approach.

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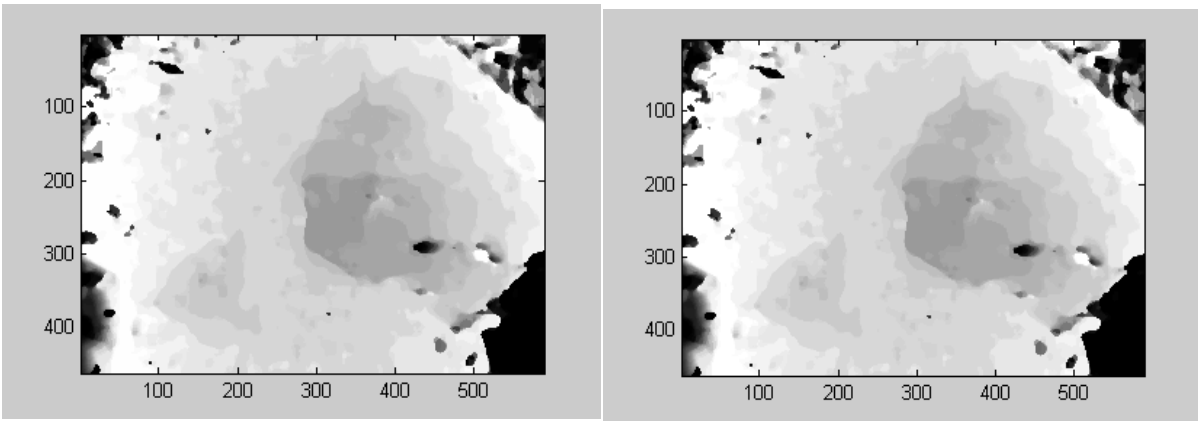

(c) (d)

Figure 2 (c) disparity result using one level of the wavelet transform (d) disparity result using two levels of the wavelet transform.

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