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Removal of High Density Impulse Noise Using Boundary Discriminative Noise Detection Algorithm

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ABSTRACT: Switching median filters are used as standard median filters for the removal of impulse noise which can do the filtering of candidate noisy pixels and leaving uncorrupted pixels. The boundary discriminative noise detection (BDND) is one powerful example in this class of filters. There are some issues related to the filtering step in the BDND algorithm that may degrade its performance. The proposed system consists of two modifications to the filtering step of the BDND algorithm to address these issues. Experimental evaluation shows the effectiveness of the proposed modifications in producing sharper images than the BDND algorithm. The standard median filter, which is a nonlinear order-statistic filter, is one of the most popular filters that is used in the removal of impulse. The development of several algorithms that build on the standard median filter to improve its performance.

I. INTRODUCTION

Channel transmission errors and faulty switching of acquisition devices may result in corrupting images with impulse noise. Pixels contaminated with impulse noise are characterized by having relatively low or high intensity values when compared to their neighbouring pixels which dramatically affect images quality and possibly make them unsuitable for human or machine vision applications. To restore the original values of noisy pixels, filtering techniques are usually applied with the objective of suppressing the noise while minimizing the distortion introduced to the sharpness of edges and details in the original image.

1.1 BDND Filter

The boundary discriminative process consist of two iterations, in which the first iteration is essentially a noise detection step which is based on clustering the pixels in the image in a localized window into three groups, namely; lower intensity impulse noise, uncorrupted pixels, and higher intensity impulse noise. The clustering is based on defining two boundaries using the intensity differences in the ordered set of the pixels in the window. The pixel is classified as uncorrupted if it belongs to the middle cluster. Otherwise it is a noisy pixel. This noise detection mechanism showed impressive detection accuracy under different impulse noise models and the second iteration will only be invoked conditionally.

Step 1) Impose a 21x21 window, which is centered on the current pixel.
Step 2) Sort the pixels in the window according to the ascending order and find the median, med, of the sorted vector Vo.
Step 3) Compute the intensity difference between each pair of adjacent pixels across the sorted vector Vo and obtain the difference vector VD.
Step 4) For the pixel intensities between 0 and med in the Vo, find the maximum intensity difference in the VD of the same range and mark its corresponding pixel in the Vo as the boundary b1.
Step 5) Likewise, the boundary b2 is identified for pixel intensities between med and 255; three clusters are, thus, formed.
Step 6) If the pixel belongs to the middle cluster, it is classified as uncorrupted pixel, and the classification process stops; else, the second iteration will be invoked in the following.
Step 7) Impose a 3x3 window, being centered on the concerned pixel and repeat Steps2)–5)
Step 8) If the pixel under consideration belongs to the middle cluster, it is classified as uncorrupted Pixel, otherwise corrupted.

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1.2 Expansion of filter window

The BDND algorithm which starts by using a 3 × 3 filtering window that is centered on the noisy pixel. The size of this window is considered insufficient for filtering under two conditions:

i) The number of uncorrupted pixels Nu is less than half of the number of pixels in the window Nh, where Nh = 1/2 (WF ×WF) and WF is the window width.

ii) If the number of uncorrupted pixels is zero. In case any of the conditions is violated for the current window, the window is expanded outward by one pixel in all directions. For the first condition, expansion is allowed as long as the size of the window is less than or equal to a maximum window size of Wmax ×Wmax.

The filtering window could be useful in providing a better estimate for the value of the noisy pixel. The strict condition of requiring the number of uncorrupted pixels to be greater than half the number of pixels in the window is easily violated under high noise densities. With high noise densities the filtering window is expected to be expanded and most likely it will reach the maximum size. The direct impact on increasing the window size is the possible loss of correlation between the pixel values inside the filtering window. It may directly affect the value that replaces the noisy pixel, which may lead to blurring and unnecessary distortion in the filtered image.

1.3 Incorporating spatial and Intensity information.

Replacing the noisy pixels with the median of uncorrupted pixels in the filtering window and forming the original image.

II. PROPOSED SYSTEM

The proposed BDND algorithms produce satisfactory results which tend to remove fine details of the image and fail to detect some of the noisy pixels, especially when the noise density is high. The interesting switching median filter is the BDND filter that is proposed. The BDND filter is proven to operate efficiently when compared to other filters, even under high noise densities (up to 90%). Being a switching-based median filter, the BDND algorithm filters the noisy image in two steps.

The first step is essentially a noise detection step which is based on clustering the pixels in the image in a localized window into three groups, namely; lower intensity impulse noise, uncorrupted pixels, and higher intensity impulse noise. The clustering is based on defining two boundaries using the intensity differences in the ordered set of the pixels in the window. The pixel is classified as uncorrupted if it belongs to the middle cluster. Otherwise it is a noisy pixel. This noise detection mechanism showed impressive detection accuracy under different impulse noise models.

Once the noise map is determined, the second step is the filtering step, which is supposed to replace the noisy pixel with an estimate of its original value. This step is applied on the identified noisy pixels only. The filtering is essentially a median filtering operation that is applied on the uncorrupted pixels found in the filtering window. The critical parameter that is required to be defined in the filtering step of the BDND algorithm is the size of the filtering window. The size of this window is determined as follows. A window of size 3 × 3 is used as initial size for the filtering window. If the number of uncorrupted pixels in the window is less than half the window size, then the window is expanded outward by one pixel in all directions. This is repeated until the number of uncorrupted pixels in the window is greater than or equal half the number of pixels in the window or the current window size is less than or equal a maximum window size. The maximum window size of the condition is ignored and the window is expanded if no uncorrupted pixels are found. In this case, window expansion is repeated until one uncorrupted pixel is found. Basically, this step is an adaptation from the filtering process proposed, and is reported to perform well even under high noise densities.

III. CONCLUSION

Switching median filters are effective in removing impulse noise as they are applied to candidate noisy pixel only. The BDND filter is one of the popular switching median filters as it is proven to overtake other filters especially at high noise densities. The filtering step imposes a strict condition on the size of the filtering window that does not take into account the noise density. Additionally, it does not consider the spatial relationship and deviation of the pixels' intensities in the filtering window from the central pixel and the median value of the window.

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Two modifications to the BDND filtering step to alleviate the effect of these problems on the quality of the filtered image. The modifications basically loosen the condition imposed on expanding the filtering window and incorporate the spatial information of the pixels in the filtering process. Experimental evaluation showed the effectiveness of these modifications on improving the performance of the BDND algorithm.

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