A method to remove image noise based on 6-tap Filter Interpolation

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Abstract. A method to remove the noise of image based on 6-tap filter interpolation is investigated in this work. To this goal, the algorithm principle of 6-tap filter interpolation including 1 / 2 pixel interpolation process, 1 / 4 pixel interpolation process and 1 / 8 pixel interpolation process are firstly analyzed. Then, in order to validate the effectiveness of 6-tap filter interpolation for the image denoising, two images added with Gaussian noise are processed by 6-tap filter interpolation and the SNR is used to evaluate the post-processing image. The obtained results show the SNR of post-image is larger than that of pre-processing image, which proves that the 6-tap filter interpolation can be acted as an effective method to remove the noise of image.

1. Introduction
Because the image acquisition is affected by the equipment and the external environment, the image usually contains abundant noise, which seriously reduces the image quality. Therefore, in order to improve the clarity and visual effect of image, it is necessary to remove the image noise.

At present, there are two methods to remove the noise of image. One is spatial domain denoising method based on processing the pixel value of image [1, 2]. This method mainly contains histogram equalization method, Gaussian filter and mean filter. The other is frequency domain denoising method based on processing spectrum of image [3-5]. This method mainly contains low-pass filter, high pass filter and wavelet transform. Compared with the above two methods, the spatial domain denoising method is relatively simple with the faster processing speed and commonly used to remove the noise of image. Therefore, this paper investigates a method that can be used to remove the noise of image based on 6 - tap filtering interpolation

2. Algorithm principle
In the 6 - tap filtering interpolation, the interpolation image with the 1 / 2 pixel accuracy is obtained by 6 - tap interpolation, and that with 1 / 4 pixel accuracy is obtained by bilinear interpolation.
Fig. 1 shows the 1/2 pixel interpolation process. From which we can find that the interpolation image with the 1/2 pixel precision is firstly obtained through the 6-tap filtering interpolation. In the 6-tap filtering interpolation, the weight of 6 points is set as \((1, -5, 20, 20, -5, 1) / 32\), and the value of 1/2 pixel point, such as \(b, h, m\), can be obtained by 6-tap filtering interpolation with corresponding integer pixels, i.e.,

\[
b = \text{round}\left(\frac{E - 5F + 20G + 20H - 5I - 5J}{32}\right)
\]  

(1)

Similarly, the value of \(h\) can be obtained by filtering the value of these points including \(A, C, G, M, R\) and \(T\). After calculating the value of 1/2 pixel point, the value of 1/4 pixel point can be obtained by linear interpolation of 1/2 pixel point.

Fig. 2 shows the 1/4 pixel interpolation process. From which we can find that these 1/4 pixel points including \(a, c, i, k, d, f, n\) and \(q\), are obtained by interpolation of the adjacent 1/2 pixels, i.e.,

\[
a = \text{round}\left(\frac{G + b}{2}\right)
\]  

(2)

The values of the remaining 1/4 pixels, such as \(e, g, p\) and \(r\), are obtained by linear interpolation of 1/2 pixels on two diagonals, i.e.,

\[
e = \text{round}\left(\frac{b + h}{2}\right)
\]  

(3)

Fig. 3 shows the 1/8 pixel interpolation process. From which we can find that in the prediction of chroma pixels, the motion vector, \(MV\), with 1/8 pixel accuracy is obtained by bilinear interpolation of the whole pixel, i.e.,
\[ a = \text{round}\left[\frac{(8-8_d)A + d_6(8-8_d)B + (8-8_d)d_6C + d_6d_6D}{64}\right] \]  

3. Case study

In order to validate the effectiveness of 6-tap filter interpolation for the image denoising, two images with number of 1# and 2# are used to process. Firstly, the Gaussian noise with the mean value of 0 and variance of 1e-3 is added to the images 1# and 2#. Then, the 6-tap Filter Interpolation is used to remove the noise and the corresponding result are shown in Fig. 4 and Fig. 5.

(a)   (b)   (c)
Figure 4. The processing results of 1#. (a). Initial image. (b). Image with noise. (c). Image after processing

(a)   (b)   (c)
Figure 5. The processing results of 2#. (a). Initial image. (b). Image with noise. (c). Image after processing
From Fig. 4 and Fig. 5, we can find that the 6-tap filter interpolation can effectively remove the noise in the images, maintain the details in the image such as lines, points and edges and enhance the image quality, which indicates the algorithm is effective.

In order to evaluate the effectiveness of the algorithm further, the Signal-to-Noise Ratio, SNR [6], is used for evaluating the image quality. The express of SNR is shown in Eq.(5).

\[
SNR = 10 \times \log \left( \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} I(i,j)^2}{\sum_{i=1}^{M} \sum_{j=1}^{N} [I(i,j) - I'(i,j)]^2} \right)
\]

(5)

Where \(I(i,j)\) is the initial image, \(I'(i,j)\) is the image after processing. \(M\) and \(N\) are the length and width of the image respectively.

The SNR was acquired by Eq. (5). The corresponding results are listed in Table 1.

| SNR | 1#     | 2#     |
|-----|--------|--------|
| Pre-processing | 5.0767 | 6.9178 |
| Post-processing | 6.0021 | 7.6711 |

As showed in Table 1, the SNR of post-processing image are 6.0021 and 7.6711, larger than that of pre-processing image of 5.0767 and 6.9178, which proves the validity of 6-tap filter interpolation investigated in this work.

4. Conclusions
In this work, a method to remove the noise of image based on 6-tap filter interpolation is investigated. 1 / 2 pixel interpolation process, 1 / 4 pixel interpolation process and 1 / 8 pixel interpolation process are analyzed. On this basis, two images are used for validating the effectiveness of the 6-tap filter interpolation. The results show that 6-tap filter interpolation investigated in this work can be acted as an effective method to remove the noise of image.

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