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AUTHOR(S): MICHAEL CANNON, M-4, MS-P912
ALEX LEHAR & FRED PRESTON, ENGLAND

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Los Alamos Los Alamos National Laboratory
Los Alamos, New Mexico 87545

Automatic Scene-Adaptive Pattern Removal

Michael Cannon

University of California, Los Alamos National Laboratory, Hydrodynamics Group
Mail Stop P912, Los Alamos, New Mexico 87545, USA

Alex Lehar and Fred Preston

British Home Office, Woodcock Hill, Sandridge
St. Albans, Hertfordshire, England

Abstract

A new method for removing periodic background patterns from pictures is presented. The basic spatial frequency composition of the pattern is determined from an estimate of the power spectrum of the picture. A digital restoration filter is then created from a modified version of the power spectrum. The method is extremely effective and can be automated.

Introduction

Frequently picture arise which are corrupted by a periodic interference pattern. Examples include the scan lines of a TV picture, a photograph taken through a chain link fence, or a fingerprint on fabric. The periodic pattern may interfere with successful interpretation of the picture because it confuses the human visual system.

Most methods to remove background patterns are based on attempts to identify fundamental frequencies of the pattern in the Fourier transform of the picture. Using information gleaned from these Fourier coefficients, the pattern is removed either convolutionally or by subtraction. (See for example Sec. 5.7 of Ref. 1). While the results of these methods are usually quite good, they are often obtained only through much operator interaction and trial and error. A major obstacle to streamlining and automating the removal of interference patterns is the difficulty in making the proper choice of Fourier coefficients. The coefficients of the pattern are often obscured by those of the scene.

Creation of digital filter

The Fourier coefficients of a periodic interference pattern dominate the power spectral estimate of the scene when the estimate is based on the averaging method of Welch'. The estimation procedure consists of first dividing up the original scene into subsections which are multiplied by a two dimensional Hanning window' to reduce edge effects. The magnitude squared of the Fourier transform of each subsection is computed, and these transforms are then averaged together to yield a power spectral estimate.

For the present application the averaging is very important. The only frequency domain quantities that will not be "averaged out" are those that are common to each subsection of the picture. This implies that the power spectrum will strongly describe the global background pattern, but be only weakly influenced by the scene itself. The large Fourier coefficients in the power spectrum accurately describe the spectral composition of the periodic interference pattern, which in this case is the background. A digital filter which suppresses these particular spatial frequencies will remove the background pattern.

Such a filter can be created from the power spectrum itself. With the exception of the peak centered at DC, the power spectrum is the inverse of the desired filter. This DC peak is easily removed by subtracting from the power spectrum an angular average of itself. The angular average is the average power as a function of $(u^2 + v^2)^{1/2}$, and is a rather smooth quantity with a central peak which closely matches the DC peak. The subtraction therefore removes the DC peak without perturbing the spectral peaks of the pattern. Any small coefficients that are not related to the large peaks are then set to zero. The required filter is obtained by multiplying the modified power spectrum by -1. The inverse Fourier transform of the filter can then be computed in order to obtain a convolution restoration kernel. Convoluting the degraded picture with the kernel results in removal of any periodic background pattern.

One might argue that in many cases the background pattern is additive rather than convolutional. In those cases it might be technically more correct to attempt a removal based on subtraction rather than convolution. We have found that even in those cases the convolutional approach is satisfactory because it avoids the careful scaling that is needed for a successful subtraction.

Details of implementation

It is important to create a restoration kernel on a large grid so that it is not excessively altered by spatial aliasing¹. This in turn implies that the power spectrum should be computed on a large grid also. We have found that consistently good results are obtained if the image subsections are 128x128 pixels square. This allows a large number of chunks to be extracted from the scene (49 overlapped chunks in a 512x512 image) and hence a fairly stable spectral estimate of the background. The resulting 128x128 restoration kernel appears to eliminate any problems with temporal aliasing. The kernel is sufficiently well behaved that a periodic convolution² can be used.

We find that the gain of the attenuating spikes in the suppression filter needs to be about -35 db in order to remove most of the visual traces of the background. This gain can be achieved by scaling the power spectrum. It is important to maintain a gain of 0db at DC to avoid altering the bias of the filtered picture.

Conclusions

We find that the above method works well on a wide range of pictures that are degraded with a periodic background pattern. The method is easily implemented and requires no trial and error to obtain a successful result. Several examples of the application of the method will accompany the oral presentation of this paper.

References

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