Stochastic Subsampling and Pixel Clustering

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Abstract - **The proposed approach utilizes the redundancy of raw image data to build the stochastically sampled digital image model. This approach suppresses the appearance of alias components in subsampled image. The numerical experiment simulating a stochastic subsampling and interpolation of an image is described and the results are discussed.**

Keywords - **raw image, redundancy, stochastic sampling, alias components, pixel clustering.**

I. INTRODUCTION

The modern digital image acquisition and processing systems are usually based on uniform bitmap for the reason of easy implementation. One or several matrices of uniformly distributed pixels contain the color amplitude data. The uniform interval between the pixels defines the limit of spatial resolution according to the Sampling Theorem [1]. Generally some information contained in the original image is lost or distorted during its digitizing. The resulting error can contain false details (artifacts, aliases) absent in original image. These artifacts include, for instance, moire, false contours, pixelation of boundaries, etc. [1].

A photorealistic image is generally considered to have an infinite spectrum of spatial frequencies. The aliases may be suppressed by using an antialiasing filter, which attenuates all spatial frequencies above the Nyquist limit. Some approximation of such filter being used in digital cameras is a double refraction plate installed immediately in front of the image sensor. Some degree of such suppression can be obtained by finite lens resolution. But generally such filters suppress or destroy the fine details of the image, but the attenuation of aliasing frequencies is still not sufficient. Some applications, for instance, processing of medical and scientific images may exclude the use of such filtering. The recent advancement in image sensor technology makes it possible to reduce the pixel size and extend the Nyquist limit. The drawback of smaller pixels is the increased noise, which requires grouping the physical pixels into larger clusters when the extension of the ISO settings or higher dynamic range is needed. Also such large images may be subsampled for easier handling in certain cases. The result is the reappearance of the aliases if a regular clustering or pixel binning is employed.

II. NUMERICAL EXPERIMENT

Original image contains a sequence of black and white bars with decreasing period. The bars are slightly inclined (by 1 degree) to facilitate the detection of digital artifacts like moire and pixelation during subsequent processing. This image contains 16384x4000 pixels. Based on the visual appearance, this size is assumed enough to provide necessary redundancy against Nyquist criterion to avoid visible aliasing even at extreme small structure period (at right border of the image).

This image was uniformly subsampled by combining 64 pixels (8x8 binning) into one to represent a model camera sensor, producing a bitmap of 2048 by 500 pixels (see Fig.1,a). Such number of pixels corresponds, for instance, to an image fragment of 10.24 mm by 2.5mm dimensions on the surface of a sensor with 5um pixels, used in modern full frame DSLRs. This virtual raw image was subjected to further stochastic (Fig.1, c,e,g) and uniform (Fig.1, b,d,f) subsampling with different rates.

The stochastic selection of pixels was performed by a simplest method, a random choice of a single pixel in an elementary square cell of n x n size, n = 2,3,5. The statistical distribution of this random selection was uniform. The reference regular subsampling was performing by selecting the same pixel in each elementary cell for the same n. All subsampled image was reconstructed by means of bilinear interpolation. It has been shown that uniform distribution of randomly selected pixels is not the best method for stochastic sampling from the viewpoint of the S/N ratio and resolution, and, particularly, Poisson and Poisson disk distribution may provide better results [2].

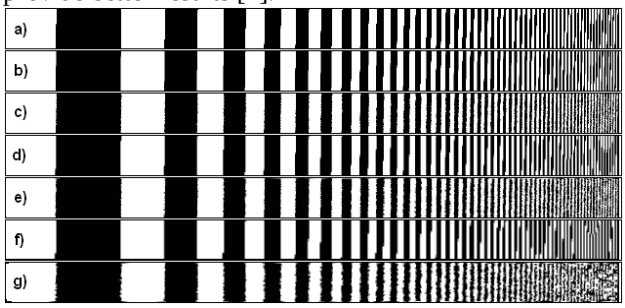

Fig.1 Virtual raw image and its recovery after subsampling

III. CONCLUSION

A stochastic subsampling model with simple linear interpolation demonstrates a potential for alias-free pixel clustering in contrary to usually adopted regular pixel binning. This method can be successfully used in processing of raw images from high resolution sensors with reduced pixel size.

REFERENCES

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