

Image Compression On-The-Fly by Universal Sampling in Fourier Imaging Systems¹

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Abstract — **An image compression system is proposed, where compression is trivially accomplished by minimally redundant acquisition, but decoding requires a nonlinear estimation step. The performance of this system is evaluated on examples and by studying the operational rate-distortion curves for a simple source model.**

I. INTRODUCTION

Many important imaging systems, including radar imaging by real or synthetic aperture (SAR), and magnetic resonance imaging (MRI), acquire samples of the 2D Fourier transform of the image, rather than the image itself. The output of these so called Fourier imaging systems is often compressed, owing to channel or storage limitations. None the less, the traditional paradigm in these systems has been to acquire large quantities of data so as to allow the formation of high resolution images, and only then exploit the redundancy in the data to compress it. Because this redundancy usually takes the form of spatial correlations, it is often only apparent after formation of the image – a computationally expensive process.

This paper considers an alternative paradigm: directly acquire minimally redundant information, simplifying, or even eliminating the need for further compression. The approach relies on new results in sampling theory [1, 2, 3], and applies to a limited but fairly wide class of so-called sparse or LSI-sparsifiable images.

II. UNIVERSAL SAMPLING AND SPECTRUM-BLIND RECONSTRUCTION

An image f will be said to be *sparse* if its support occupies only a fraction $\Omega \ll 1$ of its bounding box (i.e., most of the image pixels are zero). Let F denote the Fourier transform of f , and $*$ a 2D convolution. The class of images *sparsifiable* by the filters h and g consists of the images f for which $h * f$ is sparse, G is sparse (in the Fourier domain), and f is uniquely determined by HF and GF . For example, an image that

is piece-wise constant on a number of regions is LSI sparsifiable by h an appropriate differential operator and a G supported on the frequency axes. We show that any image in this class can be perfectly recovered from a small fraction of the Nyquist-rate samples of F , provided that the selected samples are chosen on an appropriate *universal* sampling pattern.

III. COMPRESSION BY SAMPLING

For compression, the selected samples are scalar or vector quantized, followed by entropy coding. In general, the computational requirements of this scheme, which can avoid not only the image formation step, but also the acquisition and storage of the entire data set, will be far smaller than those of the conventional system. To analyze the effectiveness of this scheme, a simple doubly-stochastic Bernoulli-Gaussian model is considered for f or for $H * f$. We compare the rate-distortion curves (computed numerically using the Blahut-Arimoto algorithm) for this source with the operational rate-distortion of the proposed scheme, and also illustrate the results on sample images.

IV. CONCLUSION

Although in general suboptimal, the proposed scheme may be of interest in asymmetric compression applications requiring very low complexity compression (with possibly high complexity decoding), or when sparse acquisition is desirable for other reasons, such as sensor cost or physical constraints.

REFERENCES

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