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An Enhanced Approach for Low Bit Rate Image Compression

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Abstract

In this proposed work, we are going to use a practical approach of uniform down sampling in image space and yet making the sampling adaptive by spatially varying, directional low-pass pre-filtering. The resulting down-sampled pre-filtered image remains a conventional square sample grid, and, thus, it can be compressed and transmitted without any change to current image coding standards and systems. The decoder first decompresses the low-resolution image and then up-converts it to the original resolution in a constrained least squares restoration process, using a 2-D piecewise autoregressive model and the knowledge of directional low-pass pre-filtering. The proposed compression approach of collaborative adaptive down-sampling and up-conversion (CADU) outperforms JPEG 2000 in PSNR measure at low to medium bit rates and achieves superior visual quality, as well. The superior low bit-rate performance of the CADU approach seems to suggest that over-sampling not only wastes hardware resources and energy, and it could be counterproductive to image quality given a tight bit budget.

Keywords: *Image Compression, Directional Pre-Filtering.*

Introduction

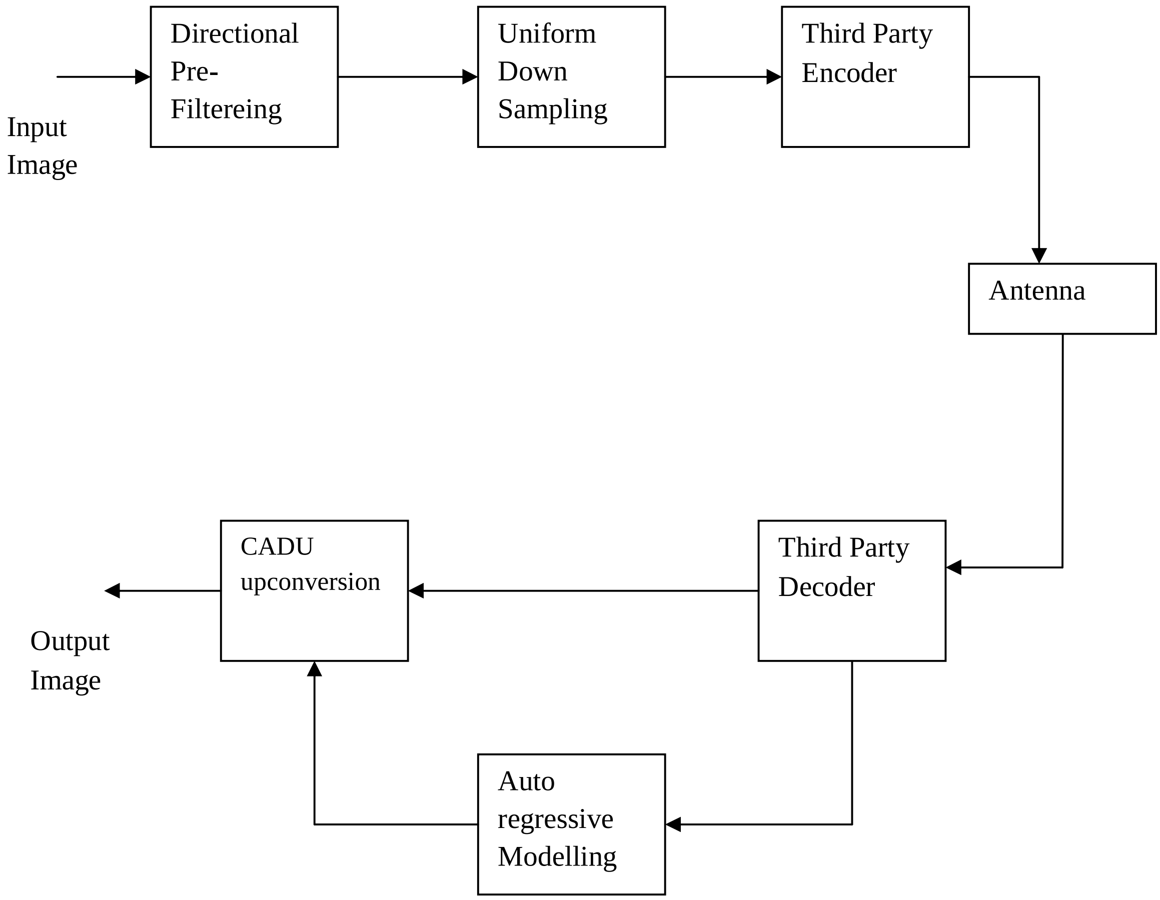
The prevailing engineering practice of image/video compression, usually starts with a dense 2-D sample grid of pixels. Compression is done by transforming the spatial image signal into a space (e.g., spaces of Fourier or wavelet bases) in which the image has a sparse representation and by entropy coding of transform coefficients. Recently, researchers in the emerging field of compressive sensing introduced a new method called "oversampling followed massive dumping" approach. They showed, quite surprisingly, it is possible, at least theoretically, to obtain compact signal representation by a greatly reduced number of random samples.

This project investigates the problem of compact image representation in an approach of sparse sampling in the spatial domain. The fact that most natural images have an exponentially decaying power spectrum suggests the possibility of interpolation-based compact representation of images. A typical scene contains predominantly smooth regions that can be satisfactorily interpolated from a sparsely sampled low-resolution image. The difficulty is with the reconstruction of high frequency contents. Of particular importance is faithful reconstruction of edges without large phase errors, which is detrimental to perceptual quality of a decoded image. For all these drawbacks, new image compression methodology of collaborative adaptive down-sampling and up conversion (CADU).

Scope of the Project

The main objective is to propose a new, standard-compliant approach of coding uniformly down-sampled images, which outperforms JPEG 2000 in both PSNR and visual quality at low to modest bit rates by using the novel up conversion process of least square no causal predictive decoding, constrained by adaptive directional low-pass profiteering. It is to estimate that a lower sampling rate can actually produce higher quality images at certain bit rates.

Block Diagram



Proposed CADU Image Compression System

Existing System

Compressive Sampling: This proposed work surveys an emerging theory which goes by the name of "compressive sampling" or "compressed sensing," and which says that this conventional wisdom is inaccurate. Perhaps surprisingly, it is possible to reconstruct images or signals of scientific interest accurately and sometimes even exactly from a number of samples which is far smaller than the desired resolution of the image/signal, e.g. the number of pixels in the image.

Disadvantages

- The number of Fourier samples we need to acquire must match the desired resolution of the image, i.e. the number of pixels in the image.

Proposed System

We propose a new, standard-compliant approach of coding uniformly down-sampled images, which outperforms JPEG 2000 in both PSNR and visual quality at low to modest bit rates. This success is due to the novel up-conversion process of least square non-causal predictive decoding, constrained by adaptive directional low-pass pre-filtering. Our findings suggest that a lower sampling rate can actually produce higher quality images at certain bit rates. By feeding the standard methods down-sampled images, the new approach reduces the workload and energy consumption of the encoders, which is important for wireless visual communication.

Advantages

- The proposed compression approach of collaborative adaptive down-sampling and up-conversion (CADU) outperforms JPEG 2000 in PSNR measure at low to medium bit rates and achieves superior visual quality, as well.

Literature Survey

[1]Compressive Sampling, Emamnuel J. Candès, Mathematics Subject Classification (2000). Primary 00A69, 41-02, 68P30; Secondary 62C65

This proposed work surveys an emerging theory which goes by the name of “compressive sampling” or “compressed sensing,” and which says that this conventional wisdom is inaccurate. Perhaps surprisingly, it is possible to reconstruct images or signals of scientific interest accurately and sometimes even exactly from a number of samples which is far smaller than the desired resolution of the image/signal, e.g. the number of pixels in the image. It is believed that compressive sampling has far reaching implications. For example, it suggests the possibility of new data acquisition protocols that translate analog information into digital form with fewer sensors than what was considered necessary. This new sampling theory may come to underlie procedures for sampling and compressing data simultaneously. In this short survey, we provide some of the key mathematical insights underlying this new theory, and explain some of the interactions between compressive sampling and other fields such as statistics, information theory, coding theory, and theoretical computer science.

[2] Structure Preserving Image Interpolation via Adaptive dautoregressive Modeling Xiangjun Zhang and Xiaolin Wu

The performance of image interpolation depends on an image model that can adapt to nonstationary statistics of natural images when estimating the missing pixels. However, the construction of such an adaptive model needs the knowledge of every pixels that are absent. This proposed work resolves this dilemma by a new piecewise 2D autoregressive technique that builds the model and estimates the missing pixels jointly. This task is formulated as a non-linear optimization problem. Although computationally demanding, the new non-linear approach produces superior results than current methods in both PSNR and subjective visual quality. Moreover, in quest for a practical solution, it breaks the non-linear optimization problem into two sub problems of linear least-squares estimation. This linear approach proves very effective in our experiments.

[3]JPEG 2000 Performance Evaluation And Assessment, Diego Santa-Cruz, Rapha¨el Grosbois and Touradj Ebrahimi

JPEG 2000, the new ISO/ITU-T standard for still image coding, has recently reached the International Standard (IS) status. Other new standards have been recently introduced, namely JPEG-LS and MPEG-4 VTC. This proposed work provides a comparison of JPEG 2000 with JPEGLS and MPEG-4 VTC, in addition to older but widely used solutions, such as JPEG and PNG, and well established algorithms, such as SPIHT. Lossless compression efficiency, fixed and progressive lossy rate-distortion performance, as well as complexity and robustness to transmission errors, are evaluated. Region of Interest coding is also discussed and its behavior evaluated. Finally, the set of provided functionalities of each standard is also evaluated. In addition, the principles behind each algorithm are briefly described. The results show that the choice of the ”best” standard depends strongly on the application at hand, but that JPEG 2000 supports the widest set of features among the evaluated standards, while providing superior rate-distortion performance in most cases.

Proposed Work

Module:

Module 1: Decompression of low –resolution image.

Module 2: Up conversion of the image to its resolution by PAR.

Module 3: Reverse the directional low-pass profiteering operation of the encoder.

Module Description

The CADU decoder first decompresses the low-resolution image and then upconverts it to the original resolution in constrained least squares restoration process, using a 2-D piecewise autoregressive model (PAR) and by reversing the directional low-pass prefiltering operation of the encoder. Two-dimensional autoregressive modeling was a known effective technique of predictive image coding For the CADU decoder, the PAR model plays a role of adaptive noncausal predictor. The CADU approach is very novel and unique that the predictor is only used at the decoder side, and the noncausal predictive decoding is performed in collaboration with the prefiltering of the encoder.

Module 1:

The CADU image compression technique, although operating on down-sampled images, obtains some of the best PSNR results and visual quality at low to medium bit rates. CADU outperforms the JPEG 2000 standard, even though the latter is fed images of higher resolution and is widely regarded as an excellent low bit-rate image codec. Since the down-sampled image has the conventional form of square pixel grid and can be fed directly to any existing image codec, standard or proprietary, the CADU upconversion process is entirely up to the decoder the proposed CADU image coding approach can work in tandem with any third party image/video compression techniques. This flexibility makes standard compliance a non issue for the new CADU method. We envision that CADU becomes a useful enhancer of any existing image compression standard for improved low bit-rate performance.

Module 2:

Out of practical considerations, we make a more compact representation of an image by decimating every other row and every other column of the image. This simple approach has an operational advantage that the down-sampled image remains a uniform rectilinear grid of pixels and can readily be compressed by any of existing international image coding standards. To prevent the down-sampling process from causing aliasing artifacts, it seems necessary to low-pass prefilter an input image to half of its maximum frequency fmax.. In areas of edges, the 2-D spectrum of the local image signal is not isotropic. Thus, we seek to perform adaptive sampling, within the uniform down-sampling framework, by smoothing the image with directional low-pass prefiltering prior to down-sampling.

Module 3:

Because the down-sampled image is only a small fraction of the original size, CADU greatly reduces the encoder complexity, regardless what third-party codec is used in conjunction. This property allows the system to shift the computation burden from the encoder to decoder, making CADU a viable asymmetric compression solution when the encoder is resource deprived. Furthermore, the superior low bit-rate performance of the CADU approach seems to suggest that a camera of unnecessarily high resolution can ironically produce inferior images than a lower resolution camera, if given a tight bit budget. This rather counter-intuitive observation should be heeded when one designs visual communication devices/systems with severe constraints of energy and bandwidth.

Algorithm Used

Collaborative Adaptive Down-sampling and Up conversion (CADU)

Future Enhancement

- CADU restoration process can be used to perform Bicubic interpolation
- Decoders of diverse capabilities can be made to work with the same code stream.

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