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Application of Super-Resolution Reconstruction of low-Resolution Image Sequences in Spatial Domain

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Abstract: In the traditional single image restoration problem only a single input image is available for processing. The task of reconstructing super-resolution images from multiple under sampled and degraded images can take advantage of the additional spatiotemporal data available in the image sequence. The principal objective is to process an image so that result is more suitable than the original image for an application. In particular, camera and scene motion lead to frames in the source video sequence containing similar, but not identical information. The additional information available in these frames make possible reconstruction of visually superior frames at higher resolution than that of the original data. This paper deals with the super-resolution reconstruction of masked and compressed gray scale images.

Keywords: Super-Resolution, Image Reconstruction, Spatial Domain, Quantization

I. INTRODUCTION

Super-Resolution reconstruction from a still image is a well-recognized example of an ill-posed inverse problem. Such problems may be approached using regularization methods, which constrain the feasible solution space by employing a-priori knowledge. This may be achieved in two complimentary ways. a) Obtaining additional novel observation data and, b) Constraining the feasible solution space with a-priori assumptions in the form of solution. Both techniques feature in modern Super-Resolution restoration methods which utilize image sequences to provide additional spatiotemporal observation constraints and various a-priori constraints on the Super-Resolution image. The use of non-linear a-priori constraints provides the potential for bandwidth extension beyond the diffraction limit of the optical system. Input is Low resolution image sequence and output is Super-Resolution reconstructed image.

A. Existing Work:

In the present scenarios image processing plays a vital role in IT and other industries which require high techniques. But the present process mainly interacts with pixels which includes compression, decompression and image processing. But there arises some problems in the present techniques such as nonavailability of originality and expected results while compression and decompression. There are three types of compression techniques, namely the two current standards used (JPEG and GIF), and the newly emerging technique of fractal compression [1].

Draw backs: Blackness results at high image compression ratios. It produces poor image quality when compressing text or images containing sharp edges or lines. It is not suitable as a strategy for images that are still being edited, because every compression/decompression cycle continues to lose information [2].

II. METHODOLOGY

The spatial resolution of a digital image is related to the spatial density of the image and optical resolution of the microscope used to capture the image. The number of pixels contained in a digital image and the distance between each pixel are a function of the accuracy of the digitizing device. All details contained in a digital image, ranging from very coarse to extremely fine, are composed of brightness transitions that cycle between various levels of light and dark. The cycle rate between brightness transitions is known as the spatial frequency of the image, with higher rates corresponding to higher spatial frequencies.

Super-Resolution techniques may be divided into two main classes –

1. Frequency domain methods - Operates on the fourier transform of an image.
2. Spatial domain methods – Operates directly on the pixels.

In Wavelet Transformation, the huge data sets are transformed to considerably smaller representations, which are then transmitted over the network at higher speeds. The data sets we are dealing with are stored in a volumetric data file format, which supports 3-D meshes [3]. The process of transformation is shown in Fig.1.

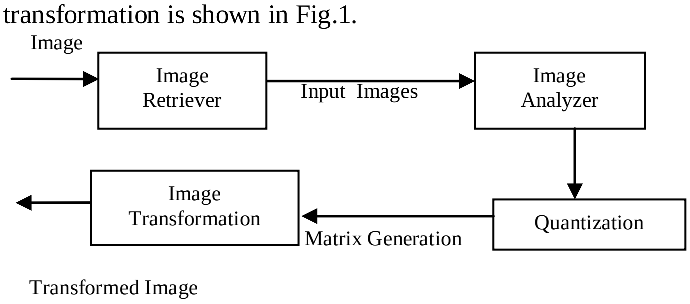

Figure.1 Phase - I System Architecture

A. Image Retriever:

The Image retriever interface defines the module responsible for supplying the reconstruction system with source image. The module accepts an image as input and sends them to the analyzer for image analysis.

B. Image Analyzer :

It is responsible for analyzing the gray scale images.

C. Quantization:

Quantization is simply the process of reducing the number of bits needed to store an integer value by reducing the precision of the integer. For every element position in the DWT matrix, a corresponding value in the quantization matrix gives a quantum value.

D. Image Transformation:

This module provides an option for the user to transform an image using spatial methodology or using wavelet transformation.

E. Wavelet Transformation:

Wavelet Transformation involves digitizing the source image into a signal s, which is a string of numbers. The signal is decomposed into a sequence of wavelet coefficients w. Thersholding is applied to modify the wavelet coefficients from w to another sequence w'. Quantization is further applied to convert w' to a sequence q. Finally entropy coding is applied to compress q into a sequence e. The wavelet images are generated using Haar wavelet transformation as shown in Fig.2 and reconstructed image is shown in Fig.3.

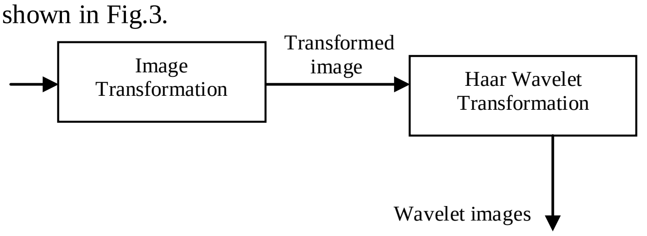

Figure. 2 Phase - II Generation of Wavelet Images

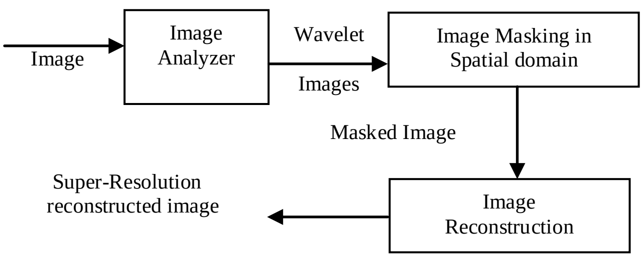

Figure. 3 Phase - III Reconstruction of Super-Resolution Images

F. Image Enhancement In Spatial Domain:

The principal objective of enhancement is to process an image so that the result is more suitable for than the original image for a specific application. It improves the interpretability or perception of information in images for human viewers. The enhancement at any point in an image depends only on the gray level at that point, they are known as Point processing techniques. Examples of such techniques are contrast stretching, thersholding which can be used for analyzing images.

III. SYSTEM UNDER DEVELOPMENT

This paper deals with conversion of original image into masked form and later back to original form using matrix method. The matrix used in this process is pixels 2X2, 4X4 up to 256X256. 256X256 is the original form. It provides support for full 24 bit images. In contrast, GIF only support 8 bit images. The compressed image size and image quality trade of can be user determined. It is ideally suited to images of real world scenes, or computer generated images which are complex. It is platform independent for displaying 24 bit images. It provides fast compression speed compared to fractal compression.

A. Super-Resolution Video Reconstruction:

For a given super-resolution frame, a sliding window determines the set of low-resolution frames to be processed to produce the output. The window is moved forward to produce successive super-resolution frames in the output sequence. The super-resolution video is enhanced from a low-resolution image sequence.

B. Factors Affecting Super-Resolution Restoration:

The various factors affecting Super-Resolution are as follows,

a. Reliable sub-pixel information is essential. Poor motion estimates are more detrimental to restoration than a lack of motion information.

b. Observation models must accurately describe the imaging system and its degradations.

c. Restoration methods must provide the maximum potential for inclusion of a-priori information.

C. Applications:

Super-Resolution techniques have been applied in the following areas like Medical Imaging, Satellite imaging, Video Surveillance, Video Enhancement and Restoration, Video Standards conversion, Microscopy and Digital Mosaicing.

IV. IMPLEMENTATION

The Haar wavelet transform is one of the simplest and basic transformations from the space domain to a local frequency domain. Haar wavelets are being used for the image transformation technique. By applying the Haar wavelet transform we can represent this image in terms of a low-resolution image and a set of detail coefficients [4]. The transformed data coefficients are obtained by averaging two consecutive pixels, while the detail coefficients represent the difference between the average and one of the two consecutive pixels. Reconstruction of the original image involves adding and subtracting the detail coefficients to and from the subsequent transformation coefficients for each cycle.

In 2D wavelet transformation, structures are defined in 2-D and the transformation algorithm is applied in *x*-direction first, and then in the *y*-direction. Similarly, in 3-D wavelet transformation the structures are defined in 3-D and the transformation algorithm is applied in *x*-, *y*- and *z*-direction successively.

A. Comparison of Spatial and Frequency Approaches:

Super-resolution reconstruction via the spatial domain addresses many of the shortcomings of frequency domain approaches[5,6]. It includes motion models, degradation models, inclusion of spatial domain a-priori knowledge for regularization and Powerful mechanism for Bandwidth Extrapolation. Comparison between Spatial and Frequency domain approaches are shown in Table 1.

Table.1 Comparison of Spatial domain and Frequency domain

Parameter	Frequency Domain	Spatial Domain
Motion Model	Global Transition	Unlimited Transition
Degradation Model	Limited	LSI or LSV
Noise Model	Limited	Very flexible, even spatially varying
Simplicity	Very simple	Generally Complex
Computational Cost	Low	High
A-priori constraints	Limited	Almost unlimited
Regularization	Limited	Excellent
Extensibility	Poor	Excellent
Performance	Good for specific applications	Good

V. CONCLUSION

Super-resolution reconstruction via the spatial domain approach addresses many of the shortcomings of frequency domain approaches. Spatial domain approaches are able to accommodate general scene observation models including spatially varying degradations, non-global relative camera/scene motion, general a-priori constraints or general noise models and provide enormous exibility in the range of degradations and observation models which may be represented and are thus the methods of choice. Thus this paper supports reconstruction of visually superior frames at higher resolution than that of the original data.

Haar wavelet transformation has enabled the transformation of huge data sets in 3-D. The image quality of the transformed image has also been satisfactory. This paper has discussed the implementation of the transformation algorithm where the entire data set is transformed. Efforts are being taken to extract sub- volumes of the data set and transform the selected volumes in order to decrease the computational time of transforming unwanted data.

VI. FUTURE ENHANCEMENTS

Future work might involve transformation of certain data at a higher resolution as compared to the rest of the data to enable the user to have a better view a particular region of interest, while rest of the data is provided as context information. The problem of high-quality video reconstruction from compressed data is also expected to have broader implications in information fusion and information theory. In future, the proposed research activities deal with fusing information spread over multiple frames in an optimal manner. In addition, they are closely related to the information content and the compressibility of video data. It can be extended for reconstruction of color images.

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