Efficient Lossless Image Compression Based on CWT

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Abstract: ***Image compression is a technique used to reduce the storage required to save an image. The existing image coding methods cannot support content based image compression and enlargement for arbitrary resolution display devices. In multimedia communications, image retargeting is generally required at the user end. The work presented in this paper addresses the increasing demand of visual signal delivery to terminals with arbitrary resolutions, without heavy computational burden to the receiving end. In this paper, the principle of seam carving and wavelet based SPIHT codec are used. For each input image, block based seam energy map is generated at the encoder side and the multilevel integer wavelet transform is performed. At the decoder side, the end user has the ultimate choice for the spatial scalability without the need to examine the visual content an image with arbitrary aspect ratio can be reconstructed in a content-aware manner based upon the side information of the seam energy map. The final result show that, for the end users, the received images with an arbitrary resolution preserve important and sensitive content while achieving high coding efficiency for transmission.***

Keywords: SPIHT, IWT, Seam Carving

1. Introduction

The basic aim of image compression is the reduction of image size for storage and transmission while maintaining an acceptable quality of reconstructed images. Generally, image compression can be classified into two kinds: lossy and lossless. Lossy compression allows that information of the original image can be lost, which doesn't produce noticeable noise for human eyes. Lossy compression has been widely used in many areas such as home entertainment, network video. Lossless compression doesn't allow any loss in compression procedure, so it is hard to achieve high compression ratio. Much of the effort has been focused on the development of lossy compression algorithms. However, certainly application such as medical image, image archiving and remote sensing image require or desire lossless compression.

Nowadays, as the size of portable devices (e.g., laptops, PDAs, and mobile phones) continue diversifying, the existing coding schemes cannot be directly applied, and an additional image retargeting process (e.g., down-sampling, cropping, warping or seam carving (SC) is needed in the receiving end. However, for the resource-limited mobile devices, it is not always possible and economical to perform sophisticated content-aware resizing. Therefore, content-based spatial-scalable image compression for arbitrary resolution is becoming one of the emergent challenges for universal access i.e., one can access any information over any network from anywhere through any type of display devices. For an arbitrary spatial-scalable image codec, it is a big challenge to reduce the amount of transmitted overhead (e.g., image content indicator and position information).

First proposed a content-aware multisize image compression scheme. The basic idea is that, by using the significance map based upon SC, an image is decomposed into two components: ROI and non-ROI. For the ROI, it is encoded by the SPIHT codec and the size is to be altered; for the non-ROI, the pixels are grouped as a sequence of seams, i.e., a connected path of low-energy pixels crossing the non-ROI region from top to bottom (a vertical seam), or from left to right (a horizontal seam). The seam information is encoded by adaptive arithmetic coding algorithm and during image decoding with the need of resizing; the seams with low energy are deleted. Experimental results in showed that the coding efficiency is far below the wavelet-based SPIHT codec: a 2.68-bpp SPIHT-coded image achieved the same peak-signal-to-noise ratio (i.e., PSNR 40.5 dB) as a 5.85-bpp seam-coded image.

Different from the schemes in the original image is considered as a whole and not divided into two components (ROI and non- ROI) while SC is performed and the resultant seam energy map is used to guide the scanning and encoding order of the IWT coefficients. The SPIHT coded bit stream and the side information of the resultant seams are transmitted to the decoder side. In this way, we can reconstruct the content-aware image with arbitrary aspect ratio. Effective resizing of images should not only use geometric constraints, but consider the image content as well. We present a simple image operator called seam carving that supports content-aware image resizing for both reduction and expansion. A seam is an optimal 8- connected path of pixels on a single image from top to bottom, or left to right, where optimality is defined by an image energy function. By repeatedly carving out or inserting seams in one direction we can change the aspect ratio of an image. By applying these operators in both directions we can retarget the image to a new size. The selection and order of seams protect the content of the image, as defined by the energy function. Seam carving can also be used for image content enhancement and object removal. We support various visual saliency measures for defining the energy of an image, and can also include user input to guide the process. By storing the order of seams in an image we create multi-size images that are able to continuously change in real time to fit a given size.

2. Background Review

We present a simple image operator called seam carving that supports content-aware image resizing for both reduction and expansion. A seam is an optimal 8- connected path of pixels on a single image from top to bottom, or left to right, where optimality is defined by an image energy function. By repeatedly carving out or inserting seams in one direction we can change the aspect ratio of an image. By applying these operators in both directions we can retarget the image to a new size. The selection and order of seams protect the content of the image, as defined by the energy function. Seam carving can also be used for image content enhancement and object removal. We support various visual saliency measures for defining the energy of an image, and can also include user input to guide the process. By storing the order of seams in an image we create multi-size images that are able to continuously change in real time to fit a given size. Let si denote the 'I'th component of a seam, and then si x and si y represent its vertical and horizontal aspects, respectively.

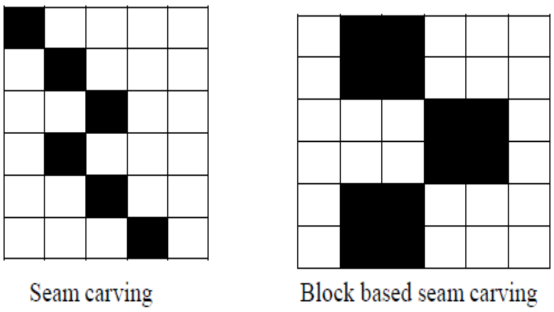

Figure 1: Basic Block Diagram of Seam Carving

In seam carving seam is pixel, for image resizing it removes or adds the seam into the image. It uses an energy function to define the importance of the pixels. High energy value indicates important pixels while low value indicates the low importance. Accordingly creating an energy map which indicates the importance of pixels in that image. But the seam carving produces high computational complexity for performing the image resizing. In this paper we uses block based seam carving. It is extended format of seam carving. This method can use for both image shrinking and enlargement. It makes use of both gradient energy and intensity value. In block based seam carving seam is a block of pixel. Block based seam carving has advantages over seam carving. It performs faster, less distortion, computational complexity less etc. it removes a block of seams for shrinking the image.

2.1 SPIHT codec

This page presents the powerful wavelet-based image compression method called *Set Partitioning in Hierarchical Trees* (SPIHT). The SPIHT method is not a simple extension of traditional methods for image compression, and represents an important advance in the field. The method deserves special attention because it provides the following properties: Highest Image Quality, Progressive image transmission, Fully embedded coded file, Simple quantization algorithm, Fast coding/decoding, Completely adaptive, Lossless compression, Exact bit rate coding, Error protection.

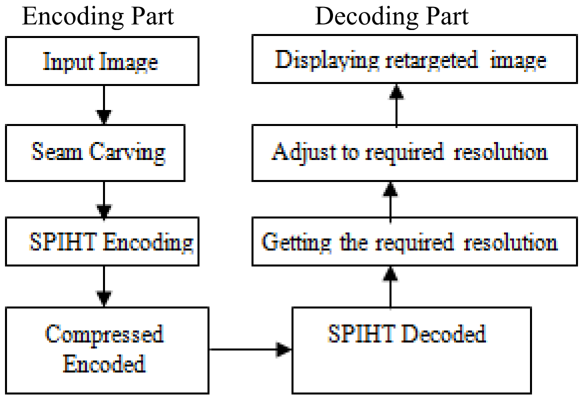

Figure 2: Program Flow of the Proposed Image Codec

3. Proposed Codec Description

In this paper, SC is applied to improve the spatial scalability of the conventional wavelet-based SPIHT scheme. The block diagram of the proposed codec is shown in fig 1.which involve two major aspects: the seam carve and SPIHT coding. In the seam carve process block based seam search process and seam energy map are included. From fig 1.we can see that, proposed image codec including encoding and decoding part.

At the encoder side original input image is considered as a whole and not divided into two components, while SC is performed and the resultant seam energy map is used to guide the scanning and encoding order of the IWT coefficients. The SPIHT coded bit stream and the side information of the resultant seams are transmitted to the decoder side, In this way, we can reconstruct the content aware image with arbitrary aspect ratio.

3.1 Integer Wavelet Transforms using the Lifting Scheme

The wavelet transform of a one-dimensional signal is a multi-resolution representation of that signal where the wavelets are the basis functions which at each resolution level give a highly decorrelated representation. Thus at each level, the (low-pass part of the) signal is split into a high-pass and a low-pass part. These high-pass and low-pass parts are obtained by applying corresponding wavelet filters. The lifting scheme is an efficient implementation of these filtering operations. So suppose that the lower solution part of a signal at level *j* + I is given as a data set Aj+l' This set is transformed into two other sets at level *j:* the low-resolution part Aj and the higher solution part *"fj*. This is obtained first by just splitting the data set *Aj+l* into two separate data subsets (usually called the *lazy wavelet transfonn).* The next step is to recombine these two sets in several subsequent lifting steps which decorrelate the two signals.

To obtain an efficient implementation of the discrete wavelet transform, it is of great practical importance that the wavelet transform is represented by a set of integers. Because if we store wavelet coefficients as a floating point values it requires 32 bits per coefficients. This is not reasonable in some applications like speech compression. Hence wavelet coefficients are rounded to convert it into integer number for efficient encoding and storage. Because of this rounding process, the original signal cannot be reconstructed from its transform without an error. This is the reason for not getting loss-less speech compression in the filter bank implementation. Using lifting scheme of wavelet transform, rounding error is cancelled during the inverse transform. Hence it is possible to achieve perfect reconstruction. This is explained below:

A *dual lifting* step can be seen as a prediction: the data *"fj* are "predicted" from the data *Aj.* When the signals are still highly correlated, then such a prediction will usually be very good, and we can store only the part of *"fj* that differs from its prediction (the prediction error). Thus *"fj* is replaced by *"fj - P(Aj},* where *P* represents the prediction operator.

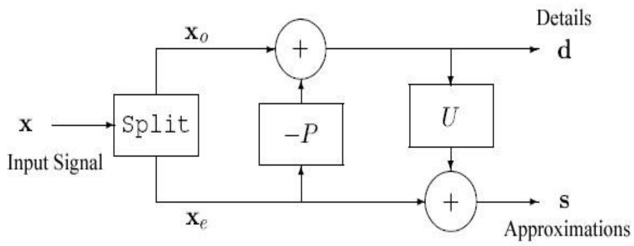

Figure 3: Forward Lifting Scheme

However, the new representation has lost certain basic properties, like for example the mean value of the signal. To restore this property, one needs a *primal lifting* step, whereby the set Aj is updated with data com puted from the (new) subset *"(j.* Thus Aj is replaced by Aj+ *U ("(j),* with *U* some updating operator. In general, several such lifting steps can be applied in sequence to go from level *j* + 1 to level *j.* To recapitulate, let us consider a simple lifting scheme with only one pair of lifting steps to go from level *j* +1 to level *j.*

Splitting *(lazy wavelet transform)* Partition the data set AHI into two distinct data sets Aj and *"(j.*

Prediction *(dual lifting)* Predict the data in the set *"(j* by the data set at *"(j "(j - P (Aj).*

Update *(primal lifting)* Update the data in the set Aj by the data in set *"(t* Aj Aj + *U ("(j).* These steps can be repeated by iteration on the Aj, creating a multi-level transform or multi-resolution decom- position. The inversion rules are obvious: revert the order of the operations, invert the signs in the lifting steps, and replace the splitting step by a merging step:

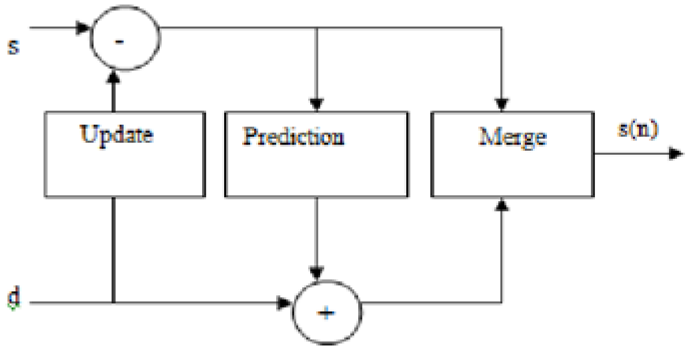

Figure 4: Inverse Lifting Scheme

4. Results And Discussion

Image resizing that changes the image to a different size is a useful and fundamental tool in many aspects in digital image processing. As the diversity and amount of digital display devices increasing, image resizing, especially retargeting resizing is more used to display images in mobile phone, PDAs and HTML that supports dynamic displaying and changing of image sizes.

I only consider the resizing function of seam carving. A seam is a path from top to bottom or from left to right through the image with each pixel in the path is 8-connected. The core idea of seam carving is to find the optimal seam containing least information in the image and remove or insert a new seam of the seam for reducing the image size or enlarging the image size. As a result, this resizing method only destroys the pixels with less importance of the whole image and protects the main feature of the image. The fundamental and most important step of seam carving is how to find the optimal seam. I calculate the energy map of the whole image and found the optimal seam with the least energy. Seam carving support different energy calculation method that definitely causes different optimal seam and pixels choice. I only implemented gradient magnitude to get the energy map of the image.

Figure 5: Original Image with 512X512

This is the input image with size 250X250.Input image is read by Seam Carving GUI for image resizing. Gradient level was calculated by the seams. The main overall functionalities include (in order from the top to bottom in the GUI) opening an image file, resetting the state of the program to initial values before the image was resized in any way, the removal of a single vertical running seam from the image, removal of a single horizontal seam from the image.

The gradient image is a common image that is used in both horizontal and vertical seam calculation, and can be calculated either from the luminance channel of a HSV image, or calculated for each of the R, G, and B channels, then averaging the three gradient images. The Sobel operator was chosen for calculation of the gradient image in this project, but other gradient operators may be used.

Figure 6: Gradient Image Conversion

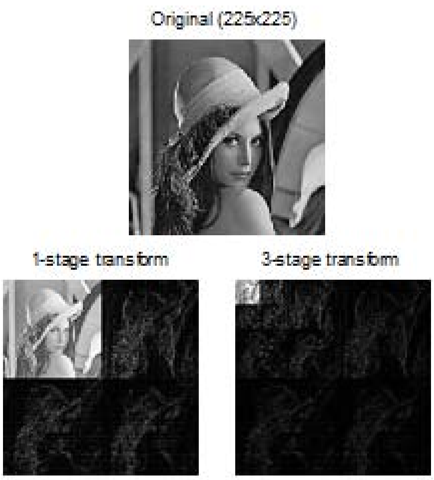

Figure 7: Output of IWT and SPIHT Coder

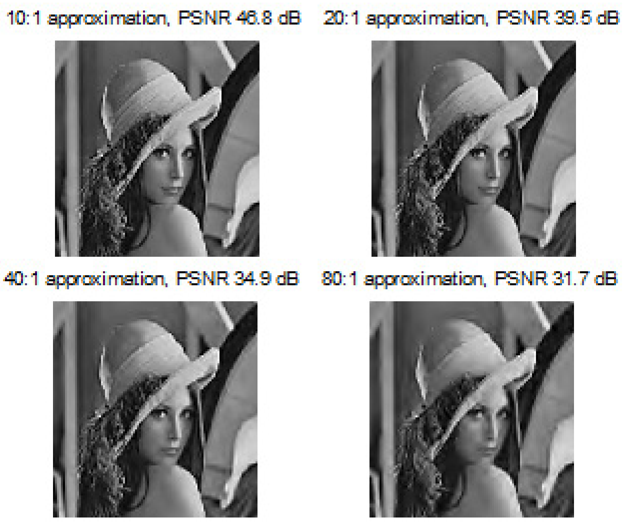

Figure 8: PSNR Analysis

Figure 9: Compressed Image Output

5. Conclusion

This paper has presented a brief overview of content-based image retrieval area for compression and enlargement. We have provided a resolution for delivering images to the diversity and versatility of display devices with arbitrary resolutions, and mentioning the important and sensitive content without extra computational burden at the receiving end. And keeps the decoder's complexity low. In this paper we are using seam carve and SPIHT coded technique. In seam-SPIHT, at the encoder side block based seam energy map is generated in the image domain. According to the resultant map, the coefficients are grouped as seam-guided SOTs, Which are encoded in energy descendant order and the side information is also sent to indicate the positions of trees. In this way, one can reconstruct the arbitrary size image in a content-aware manner. Experimental results have shown that the retargeted images generated by the proposed codec preserve important and sensitive image content (i.e., in a content-aware manner), while achieving better compression and enlargement performance compared with the existing relevant coding schemes.

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