FPGA IMPLEMENTATION OF IMAGE COMPRESSION USING SPIHT ALGORITHM

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Abstract- The demand for multimedia products have been growing fast,but consume large amount of storage space.Therefore the theory of compression becomes more significant in information theory for reducing transmission bandwidth and memory.Compression is the process of encoding data using fewer bits.Image compression reduces the amount of data required to represent an image.The objective of image compression is to reduce the redundancy of image and to store or transmit the image in an efficient form.The combination of DWT and SPIHT algorithm is used for image compression technique in FPGA.Set Partitioning in Hierarchial Trees(SPIHT) is a wavelet based image compression that offers good image quality,fast coding and high PSNR.It is used for lossless image compression. It can compress and reconstruct the image without changing the originality and the quality of the image.

Keywords: Image compression,Wavelet transform,DWT,SPIHT,FPGA.

BACKGROUND STUDY

The identification of objects in an image and this process would probably start with image processing techniques such as noise removal, followed by (low-level) feature extraction to locate lines, regions and possibly areas with certain textures.

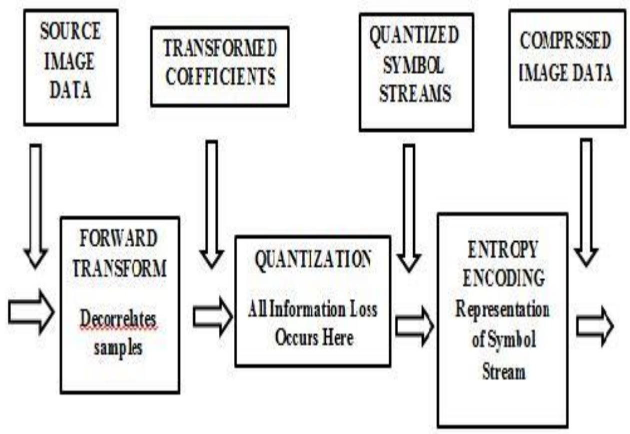
The clever bit is to interpret collections of these shapes as single objects, e.g. cars on a road, boxes on a conveyor belt or cancerous cells on a microscope slide. One reason this is an AI problem is that an object can appear very different when viewed from different angles or under different lighting. Another problem is deciding what features belong to what object and which are background or shadows etc. The human visual system performs these tasks mostly unconsciously but a computer requires skillful programming and lots of processing power to approach human performance. In computers,manipulation of data in the form of an image is through several possible techniques. An image is usually interpreted as a two-dimensional array of brightness values, and is most familiarly represented by such patterns as those of a photographic print, slide, television screen, or movie screen. An image can be processed optically or digitally with a computer.

To digitally process an image, it is necessary to reduce the image to a series of numbers that can be manipulated by the computer. Each number representing the brightness value of the image at a particular location is called a picture element or a pixel. A typical digitized image may have 512 × 512 or roughly 250,000 pixels, although much larger images are becoming common. Once the image has been digitized, there are three basic operations that can be performed on it in the computer. For a point operation, a pixel value in the output image depends on a single pixel value in the input image. For local operations, several neighbouring pixels in the input image determine the value of an output image pixel. In a global operation, all of the input image pixels contribute to an output image pixel value.

A digital image obtained by sampling and quantizing a continuous tone picture requires an enormous storage. For instance, a 24 bit colour image with 512x512 pixels will occupy 768 Kbyte storage on a disk, and a picture twice of this size will not fit in a single floppy disk. To transmit such an image over a 28.8 Kbps modem would take almost 4 minutes. The purpose for image compression is to reduce the amount of data required for representing sampled digital images and therefore reduce the cost for storage and transmission. Image compression plays a key role in many important applications including image database, image communications, remote sensing (the use of satellite imagery for weather and other earth-resource application). The image(s) to be compressed are gray scale with pixel values between 0 to 255. There are different techniques for compressing images. They are broadly classified into two classes called lossless and lossy compression techniques. As the name suggests in lossless compression techniques, no information regarding the image is lost. In other words, the reconstructed image from the compressed image is identical to the original image in every sense. Whereas in lossy compression, some image information is lost, i.e. the reconstructed image from the compressed image is similar to the original image but not identical to it.

Image compression addresses the problem of reducing the amount of data required to represent a digital image. The underlying basis of the reduction process is the removal of redundant data. From a mathematical viewpoint, this amounts to transforming a 2-D pixel array into a statistically uncorrelated data set. The transformation is applied prior to storage and transmission of the image. The compressed image is decompressed at some later time, to reconstruct the original image or an approximation to it.

The image sample first goes through a transform, which generates a set of frequency coefficients. The transformed coefficients are then quantized to reduce the volume of data. The output of this step is a stream of integers,



each of which corresponds to an index of particular quantized binary. Encoding is the final step, where the stream of quantized data is converted into a sequence of binary symbols in which shorter binary symbols are used to encode integers that occur with relatively high probability. This reduces the number of bits transmitted.

PROPOSED WORK

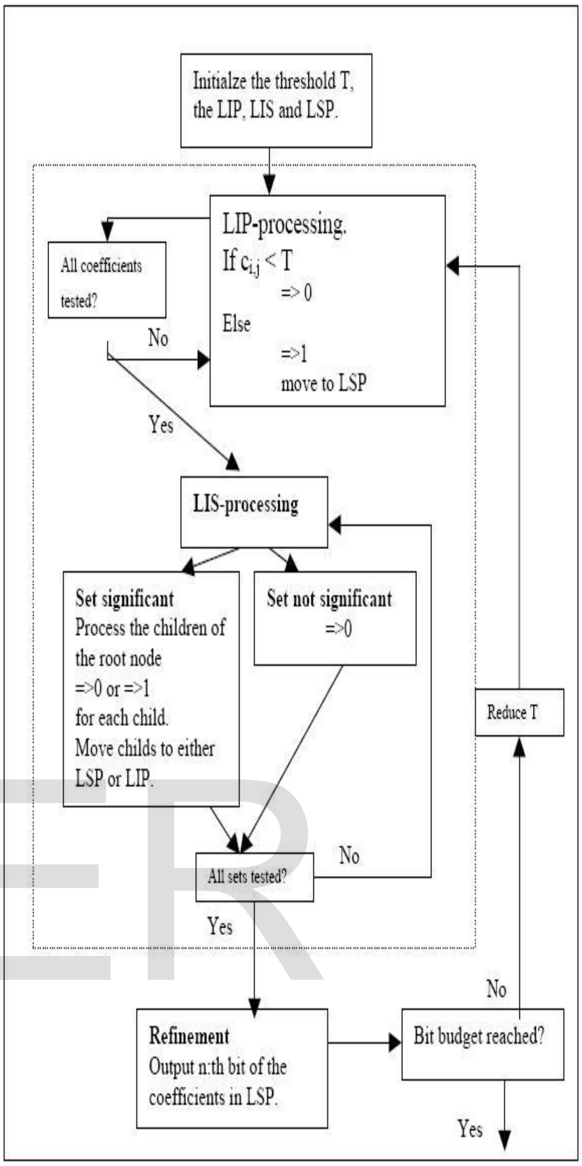
Set partitioning in hierarchical trees (SPIHT) is an image compression algorithm that exploits the inherent similarities across the subbands in a wavelet decomposition of an image.

SPIHT consists of two passes, the ordering pass and the refinement pass. In the ordering pass SPIHT attempts to order the coefficients according to their magnitude. In the refinement pass the quantization of coefficients is refined. The ordering and refining is made relative to a threshold. The threshold is appropriately initialised and then continuously made smaller with each round of the algorithm. SPIHT maintains three lists of coordinates of coefficients in the decomposition. These are the List of Insignificant Pixels (LIP), the List of Significant Pixels (LSP) and the List of Insignificant Sets (LIS). To decide if a coefficient is significant or not SPIHT uses the following definition. A coefficient is deemed significant at a certain threshold if its magnitude is larger then or equal to the threshold. Using the notion of significance the LIP, LIS and LSP can be explained. The LIP contains coordinates of coefficients that are insignificant at the current threshold, The LSP contains the coordinates of coefficients that are significant at the same threshold.The LIS contains coordinates of the roots of the spatial parent-children trees .

1.In the ordering pass of SPIHT (marked by the dotted line in the schematic above) the LIP is first searched for coefficients that are significant at the current threshold, if one is found 1 is output then the sign of the coefficient is marked by outputting either 1 or 0 (positive or negative). Now the significant coefficient is moved to the LSP. If a coefficient in LIP is insignificant a 0 is outputted.

2. Next in the ordering pass the sets in LIS are processed. For every set in the LIS it is decided whether the set is significant or insignificant. A set is deemed significant if at least one coefficient in the set is significant. If the set is significant the immediate children of the root are sorted into LIP and LSP depending on their significance and 0s and 1s are output as when processing LIP. After sorting the children a new set (spatial coefficient tree) for each child is formed in the LIS. If the set is deemed insignificant, that is this set was a zero-tree, a 0 is outputted and no more processing is needed. The above is a simplification of the LIS processing but the important thing to remember is that entire sets of insignificant coefficients, zero-trees, are represented with a single 0. The idea behind defining spatial parent-children relationships as in is to increase the possibility of finding these zero-trees.

3.The SPIHT algorithm continues with the refinement pass. In the refinement pass the "next bit" in the binary representation of the coefficients in LSP is outputted. The "next bit" is related to the current threshold. The processing of LSP ends one round of the SPIHT algorithm, before the next round starts the current threshold is halved.



FLOW DIAGRAM OF SPIHT WORKING

Extensive research has shown that the images obtained with wavelet-based methods yield very good visual quality. At first it was shown that even simple coding methods produced good results when combined with wavelets and is the basis for the most recently JPEG2000 standard. However, SPIHT belongs to the next generation of wavelet encoders, employing more sophisticated coding. In fact, SPIHT exploits the properties of the wavelet-transformed images to increase its efficiency.

Many researchers now believe that encoders that use wavelets are superior to those that use DCT or fractals. We will not discuss the matter of taste in the evaluation of low quality images, but we do want to say that SPIHT wins in the test of finding the minimum rate required to obtain a reproduction indistinguishable from the original. The SPIHT advantage is even more pronounced in encoding color images, because the bits are allocated automatically for local optimality among the color components, unlike other algorithms that encode the color components separately based on global statistics of the individual components.

SPIHT PARAMETERS:

1 PSNR:

PSNR is used to find out the ratio between the maximum power of a signal and the noise corrupted signal that affects the reliability of the signal representation.It is a measurement to measure the quality of the image.The high PSNR value denotes the reconstructed image quality is high and low PSNR value denotes the reconstructed image quality is low.

$$PSNR = 10\log_{10}(\text{——})$$

2 MSE:

MSE is the metric used to verify the mean square error of the image.The MSE is used to estimate the difference between two images in terms of squared error value.

$$MSE = \frac{))}{\quad}$$

3 COMPRESSION RATIO:

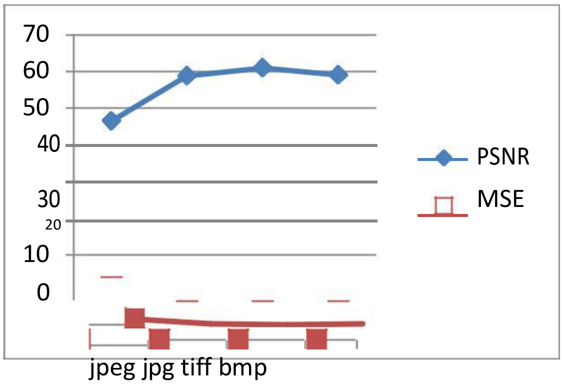
Data *compression ratio*, also known as *compression* power, is a computer science term used to quantify the reduction in data-representation size produced by a data *compression* algorithm. The data *compression ratio* is analogous to the physical *compression ratio* used to measure physical *compression* of substances.

COMPRESSION RATIO= ————————

RESULTS

IMAGE SIZE	COMPRESSED IMAGE	RECONSTRUCTED IMAGE	PSNR	MSE
64x64			45.0077	2.0526
128x128			48.2887	0.9643
256x256			50.3291	0.6028
512x512			53.6311	0.2818

PSNR & MSE Vs IMAGE TYPES FOR IMAGE SIZE 256x256



SPIHT proves and compromises that it can compress and reconstruct the image without changing the originality and the quality of the input image.From the experiment results it can be concluded that the SPIHT algorithm is effective and efficient than the existing approaches in terms of PSNR,MSE and compression ratio.

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