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Compression of Image Using DCT, VLC and Huffman Coding

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***Abstract*— in wireless sensor network, there is camera on a node that capture image and transmit to base station. The cameras are static and periodically capture an image that is transmitted back to the base station. The base station then inserts the images in a database that can be accessed over the Internet. There are limited resources for camera nodes like processing power, bandwidth and energy. Since the nodes are battery powered and are supposed to run for a long time without the need for service from a user the energy consumption is a very important issue. By shutdown the hardware of camera then power can be save as possible between images are taken. To reduce the time needed to transmit an image can be done by using an efficient algorithm for compression. These compression algorithms are DCT, VLC and Huffman coding by which an image can be compressed.**

***Keywords*— WSN, Compression, DCT, VLC, Huffman Coding.**

I. INTRODUCTION

Wireless Sensor Networks (WSN) are a new tool to capture data from the natural or built environment at a scale previously not possible. A WSN typically have the capability for sensing, processing and wireless communication all built into a tiny embedded device. This type of network have drawn increasing interest in the research community over the last few years, driven by theoretical and practical problems in embedded operating systems, and distributed signal processing. In addition, the increasing availability of low-cost CMOS or CCD cameras and digital signal processors (DSP) has meant that more capable multimedia nodes are now starting to emerge in WSN applications. [1] This has led to recent research field of Wireless Multimedia Sensor Networks (WMSN) that will not only enhance existing WSN applications.

II. INTRODUCTION TO IMAGE COMPRESSION

Compression refers to reducing the quantity of data used to represent any type of media file like audio, video and image content without excessively reducing the quality of the original data. Data compression on digital images is known as application of image compression.

The main purpose of image compression is to reduce the redundancy and irrelevancy present in the image, so that it can be stored and transferred efficiently. Less number of bits are used to represent of a compressed image as compared to original. Hence, the required storage size will be reduced, so many images can be stored in less space and it can transferred in faster way due to which required time less as compared to original.

For this purpose many compression techniques i.e. differential encoding, predictive image coding, transform coding have been introduced. Transform coding is most efficient especially at low bit rate. Depending on the compression techniques the image can be reconstructed with and without perceptual loss. In lossless compression, the reconstructed image after compression is numerically identical to the original image. Reconstructed image contains degradation relative to the original in case of lossy compression. Lossy technique causes image quality degradation in each compression or decompression step [3]. In general, lossy techniques is provide for greater compression ratios than lossless techniques, but yields only less compression whereas the lossy compression techniques lead to loss of data with higher compression ratio.

Image compression may be lossy or lossless. For archival purposes technique of lossless compression is used and often for medical imaging, technical drawings, clip art, or comics. Lossy compression methods, especially when used at low bit rates then compression of image introduce. Natural images use lossy methods such as photographs in applications where minor (sometimes imperceptible) loss of fidelity is acceptable to achieve a substantial reduction in bit rate. Imperceptible differences are produces by lossy compression that may be called visually lossless.

Compressing an image is significantly different than compressing raw binary data. Of course, general purpose compression programs can be used to compress images. Statistical properties which can be exploited by encoders specifically designed for them. The image can be sacrificed for the sake of saving a little more bandwidth or storage space. This also means that lossy compression techniques can be used in this area.

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Lossless compression involves with compressing data which, when decompressed, will be an exact replica of the original data. This is the case when binary data such as executables, documents etc. are compressed. They need to be exactly reproduced when decompressed. On the other hand, images (and music too) need not be reproduced 'exactly'. An approximation of the original image is enough for most purposes and the compressed image is tolerable.

III. PREPROCESSING

The first step is to capture and pre-process the image. A CCD camera consists of a 2-D array of sensors, each corresponding to a pixel. Each pixel is then often divided into three subareas each sensitive for a different primary color. The most popular set of primary colors used for illuminating light sources are red, green and blue, known as the RGB-primary. Since the human perception for light is more sensitive for luminance in-formation than for chrominance information another color space is often desired [4]. There are also historical reasons for a color space separating luminance and chrominance information. The first television systems only had luminance white") information and chrominance (color) was later added to this system. The YUV color space use one component, Y, for luminance and two components, U and V, for chrominance.

IV. DCT

In signal processing, Discrete Cosine Transform (DCT) is mostly used as transform function. It transforms a signal from spatial domain to frequency domain. It has been used in JPEG standard for image compression. DCT has been applied in many fields such as data compression, pattern recognition, and image processing, and so on.

The DCT transform and its inverse manner can be expressed as follows:

$$F(u,v)=\frac{4C(u)C(v)}{n^2}\sum_{j=0}^{n-1}\sum_{k=0}^{n-1}f(j,k)\cos[\frac{(2j+1)u\pi}{2n}]\cos[\frac{(2k+1)v\pi}{2n}].$$

$$f(j,k)=\sum_{u=0}^{n-1}\sum_{v=0}^{n-1}C(u)C(v)F(u,v)\cos[\frac{(2j+1)u\pi}{2n}]\cos[\frac{(2k+1)v\pi}{2n}].$$

Where $C(w)=1/\sqrt{2}$ When $w=0$

$C(w)=1$ when $w=1, 2, 3\dots n-1$

As an image transformed by the DCT, it is usually divided into non-overlapped $m \times m$ block. In general, a block always consists of 8´8 components [2].

Frequency components of DCT block should be high frequency, because of the heavy quantization of coefficients during JPEG compression. If the embedding factor M is chosen small, embedding the watermark in lowest frequency components will be more desirable that are least likely to be quantized in JPEG compression. The flow chart of the algorithm is shown in figure 1.

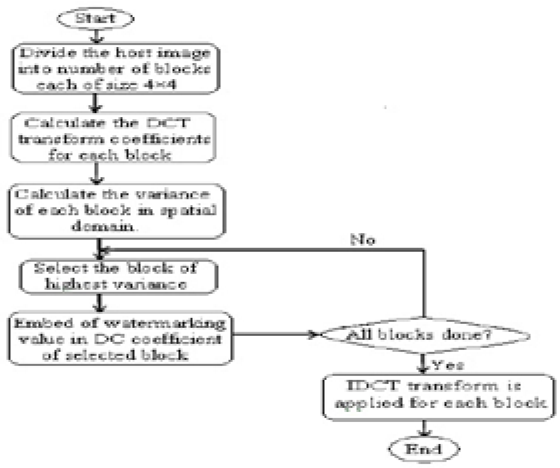

Fig. 1: The DCT algorithm flow chart

V. QUANTIZATION

In lossy image compression quantization is used to reduce the amount of data needed to represent the frequency coefficients produced by the DCT step. This is done by representing the coefficients using less precision. The large set of possible values for a coefficient is represented using a smaller set of reconstruction values. In this project a uniform quantization is used.

The human vision is rather good in discover small changes in luminance over a large area compared to discover fast changes in luminance or chrominance information. Different quantization step-sizes are therefore used for different coefficients [5]. More information is reduced for high frequency coefficients compared to low frequency coefficients. The information for the chrominance coefficients is also reduced more compared to the luminance coefficients.

VI. IMPLEMENTATION RESULT

The result of this thesis work was a system to transmit compressed images from a camera node over a wireless connection to a database that could be access using the Internet. The compression rate varies depending on the content but is usually between 90% and 99% compared to the previous camera network.

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The system can handle several cameras and when more cameras are added they will be scheduled to take and transmit images at different times. Since it is expensive in terms of energy consumption to power up and power down the camera it will take a sequence of images each time it is powered up. These images are then reconstructed to a video clip at the base station. The number of images to take each time the camera powers up can be set as a parameter when the system is started. The first image in the sequence and the video clip is added to the database to be accessible over the Internet.

A small tested containing a solar-powered camera node and a base station was set up at the Brisbane site. This system was running stable for several days.

In these remonstrations several cameras could be added to the network. Since power saving features was not used here and the cameras was always powered on it was possible to use very tight scheduling between cameras. The reason for this modification was to create a more interesting demonstration compared to the real system where nodes are put to sleep most of the time to save power.

Fig 2: Sample taken for implmentation

VII. CONCLUSION

The major components to implement were the DCT transform and the VLC and Huffman coding. The DCT transform had to be optimized and portable to run both on the DSP and on the Java listener. The algorithm used for DCT transform is one of the fastest available; however no low-level optimization of the code on the DSP was done.

Currently encoding and transmission of an image takes in the order of one second. This will make it possible to only send very low frame rate video. It should however be possible to enable high frame rate video by optimize the code and reduce the resolution slightly.

The implementation of the wireless communication on the FleckTM was done in TinyOS and NesC. This is a little different programming language and some time was required to get used to it.

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