High Performance Static Image Compression on DSP

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Abstract Providing a low-cost solution on static image procession. In this system, digital signal processor(DSP) is the core of high performance compression and image data procession. The system uses CCD for getting digital image, uses a 16 bit fix-point DSP to perform fast discret cosine transform(DCT) arithmetic and image encoding and realizes a fast image compression in end. The compression result testifies the high performance of the system.

Key words static image; forward discrete cosine transform; JPEG standard; DSP implementation

基于DSP的高性能静态图像压缩

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【摘要】提供了一种低成本的数字图像处理解决方案。研究了以DSP为核心的高性能压缩和处理系统。系统使用CCD获取原始数字图像数据，采用快速算法实现了核心的二维DCT变换，经过编码后，在一个16位定点DSP上实现了快速图像压缩。实验证明，该系统性能良好。

关 键 词 静态图像；快速离散余弦变换；JPEG标准；DSP实现
中图分类号 TP391 **文献标识码** A

With the development of Internet and consumer electronics, multimedia technology, including audio, video, static image and etc, has been widely used in various kinds of applications. Digital images, which were once a dream for most people, become a degage and simple procedure ascribing to the appearance of digital camera. For the reason that Digital Signal Processor (DSP) is the core of digital camera in general, the research of implementation of real time image procession on DSP is important. The goal of this thesis is to establish a high performance image processing encoding system on DSP.

1 System Introduction

The sample of high performance image processing is showed in Fig.1.

While pressing a key, the Video Graphic Array(VGA) digital image sensor begins to be photosensitized .The raw data is saved in an external Random Access Memory(RAM). After DSP's color processing and image

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compression, the compressed image is saved in a Smart Media Card.

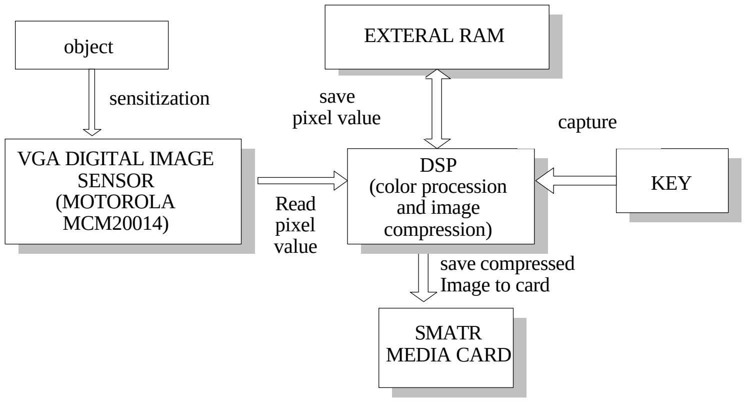


Fig.1 The schematic of the system

2 Summary of JPEG Standard

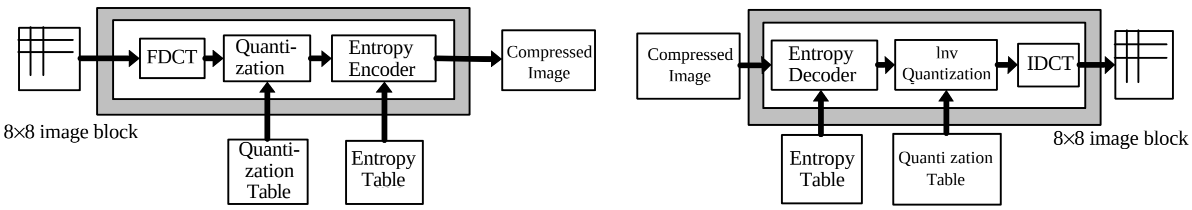
The algorithm based on discrete cosine transform (DCT) compresses images with loss information. It makes use of the special character of human' s visual system, using quantization and lossless encoding to reduce the redundant information of visual and data itself. The flow procedure diagram of Joint Picture Expert Group(JPEG) is showed in Fig.2. There are three steps in compression and coding[1]:

1) Using forward discrete cosine transform (FDCT) to mapping the image from space domain to frequency domain.

2) Quantizing DCT coefficient using weighted function. This function is the best one for human visual system.

3) Encoding the quantized coefficient with Huffman variable length code (VLC) encoder. Decompression is exactly the opposite.

The algorithm is independent from color space, so the conversion between RGB and YUV is not included in JPEG algorithm. The target for processing with JPEG is the singly color component, so that it can be used to compress data from different color space, such as RGB, YCbCr, CMYK.



(a) Compression based on DCT (b) Decompression based on DCT

Fig.2 The flow diagram of JPEG, compression and decompression

3 Implementation of Image Compression on DSP

3.1 System Design of Compression

There are several implement methods for ISO/IEC 10918. They are algorithm based on DCT and algorithm based on DPCM. We choose the algorithm based on DCT because it can compress image by ratio of 12～30 in general, with almost imperceptible loss.

There are two categories in DCT method: basic system and the extended system. The basic system is the minimal set for DCT encode and decode. For most applications , the basic system can meet their requirements. Our application must work very fast while its result may not be very fine pattern. So we' ve decided to use the DCT basic system as our application prototype.

The DCT basic system is designed as:

1) Precision of input image is 8bits/pixel/colour;

2) Encoding model is sequence model;

3) Two Huffman tables for DC encoding;

4) Two Huffman tables for AC encoding.

3.2 Implementation of the System

3.2.1 FDCT

It is necessary to use fast arithmetic to process 2D_DCT transform, for the formula of 2D DCT transform costs lots of multiplication and addition. There are many fast arithmetic for 2D DCT. The number of mathematic operation is greatly reduced through symmetry in these arithmetic. The 2D DCT fast arithmetic are efficient but complicated. Another type of fast arithmetic is optimizing 1D DCT. Such arithmetic is to take 1D DCT as the kernel of 2D DCT, and make 2D DCT realized simply by operating 1D DCT 16 times. The next diagram is the 1D DCT fast arithmetic.

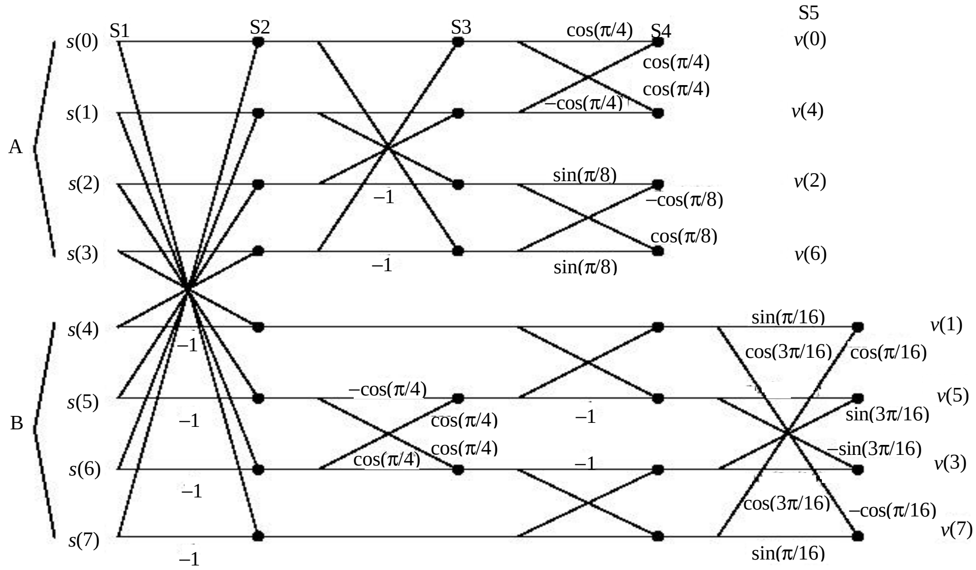


Fig.3 1D DCT fast arithmetic

3.2.2 Quantization

After the FDCT is computed for a given block, each of the 64 resulting DCT coefficients, S is quantized by an independent uniform quantizer. The quantizer step for each coefficient is the value of the corresponding element, Qvu , from the quantization table.

Quantization

$$Sq_{vQ} = round\left(\frac{S_{vQ}}{Q_{vQ}}\right) \tag{1}$$

3.2.3 Huffman Coding

We can implement Huffman coding very simply by means of lookup table. We allocate shorter codes to those symbols that frequently appear, while we assign the longer codes to the symbols that seldom appear. This kind of VCL Huffman tables could be defined in advance. The Huffman tables used in this application is recommended by JPEG and it can meet the detail requirement of most applications. There are 4 tables in this system, two for DC coefficient and two for AC coefficient. Those 4 tables are saved in an assigned block of memory in on-chip ROM[2].

3.3 System Testing and Optimization

We use Motorola 56800E processor as the image procession unit. The methods used in this implementation maintain precision while optimizing the algorithm for use with the Motorola 56800E processor. All rounding operations were performed with the 56800E rounding capabilities through the MPYR and MACR instructions[3]. The precision and accuracy were confirmed by testing the output of the function against the output of a floating point C implementation and deriving the RMS error over the 8x8 block data. The program size and execution speed are shown in Tab.1. Tab.2 shows the time statistic of compressing an image and some captured pictures.

Tab. 1 Program cycle count and memory

Code Segment	Cycle Count	Program Words
Init	7	4
Data	30	7
Kernel	1 303	109

Tab. 2 Time of image compression

Image size	Compression quality	Compression time/s
640×480	80	0.7
1 024×768	80	2.0

4 Conclusion and Prospect

The structure of DSP makes it efficient for image compression. The on-chip MAC (Multiplier-Accumulator) is a fast and high-performance way to execute calculation of FFT or DCT. It can be widely used in low cost solution of digital camera, MP3 and other applications.

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