JPEG Baseline Sequential Codec 16

The JPEG baseline sequential coder-decoder is one of the digital-image codecs that has been specified by the Joint Photographic Experts Group, a joint ISO and CCITT technical committee. The JPEG lossless compressor discussed in Chapter 17, “JPEG Lossless Codec,” is another of these codecs. Taken together, the JPEG codecs are meant to provide a standard means of compressing still continuous-tone (grayscale and color) images.

The JPEG standard was originally developed for use in areas such as desktop publishing, graphic arts, medical imaging, and document imaging, where the archiving of still images is important. However, the introduction of high-performance hardware capable of coding and decoding JPEG images in real-time has enabled the development of full-motion video applications based on JPEG.

This chapter is divided into four sections. The first section explains how the compressor works and the type of applications it was designed for. The second explains briefly how to create a JPEG baseline sequential CIS. The third discusses CIS attributes that apply specifically to the baseline sequential codec (as opposed to the general CIS attributes covered in the section “General CIS Attributes” on page 257). The fourth introduces the subject of accelerating the playback of JPEG bitstreams. For further information on this subject, see Chapter 21, “Acceleration in XIL Programs.”

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How the JPEG Baseline Sequential Codec Works

The JPEG baseline sequential compressor is one of the DCT-based compressors, which also include the MPEG-1 and H.261 compressors. Figure 16-1 shows the basic steps the compressor uses to compress an image.

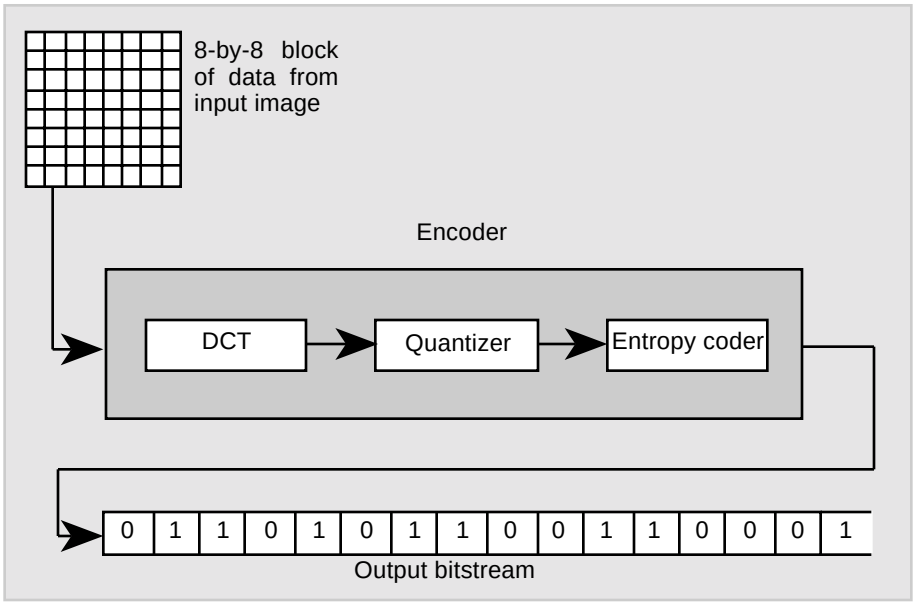

Figure 16-1 JPEG Baseline Sequential Compressor

As the figure indicates, the input to the encoder is an 8-by-8 block of samples from the image being compressed. The compressor encodes each block of data in an image by:

- Performing a Discrete Cosine Transform (DCT) on the 8-by-8 block of data
- Quantizing the results of the DCT
- Entropy coding the results of the quantization step

Each of these steps is considered in more detail in the sections below.

Discrete Cosine Transform

The Discrete Cosine Transform is a mathematical operation that takes a block of image samples as its input and converts the information in that input from the spatial domain to the frequency domain. For example, in JPEG, the input to the DCT is an 8-by-8 matrix whose values represent brightness levels at particular *x*, *y* coordinates, and the output is an 8-by-8 matrix whose values represent relative amounts of the 64 spatial frequencies that make up the input data's spectrum. In the output matrix, information about the lowest frequencies is stored in the upper-left corner, and information about the highest frequencies is stored in the lower-right corner. See Figure 16-2.

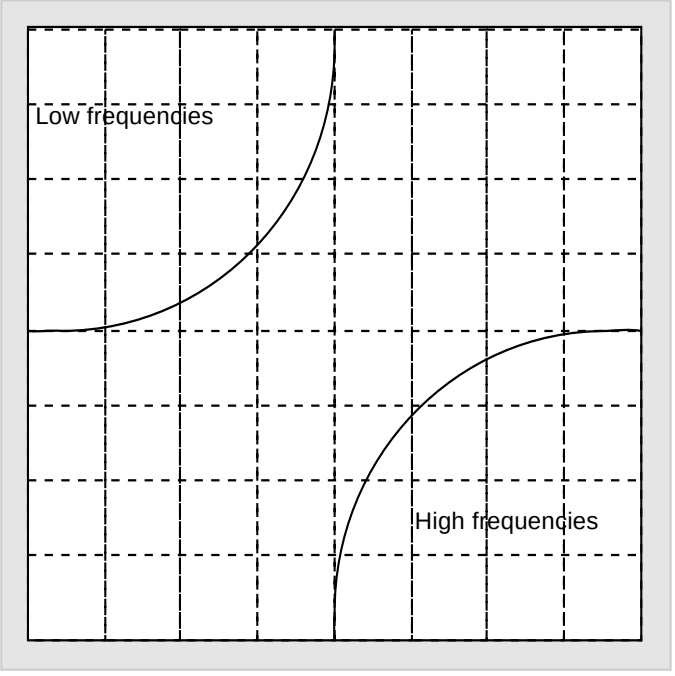

Figure 16-2 Output of the Discrete Cosine Transform

This transformation provides a strong basis for compression because in a typical block of input, low spatial frequencies far outweigh high spatial frequencies. As a result, most of the values in the output matrix, outside of those in the upper-left corner, will have values close to 0 and will end up not being encoded.

Quantization

Quantization is the simplest step in the encoder's algorithm. It simply involves dividing each value in the matrix output by the DCT by the corresponding value in a quantization table.

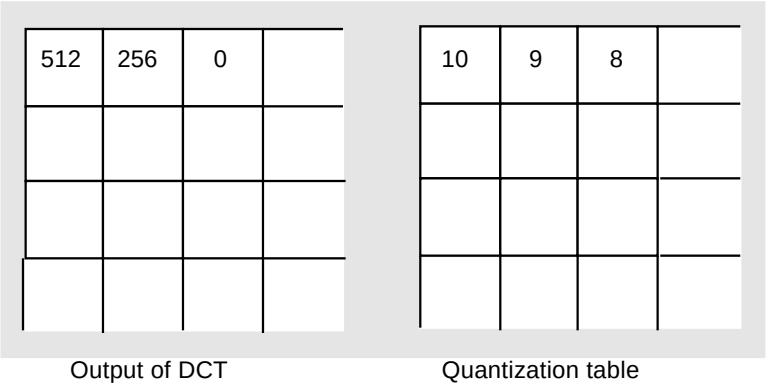

Figure 16-3 Quantization in the JPEG Encoder

Figure 16-3 shows part of an 8-by-8 block of values output by the Discrete Cosine Transform and part of a table to be used in quantizing this data. In this example, the quantizer will divide 512 by 10 and then round 51.2 off to 51. Likewise, it will divide 256 by 9 and 0 by 8. During quantization, any value in the matrix on the left that is divided by a number greater than itself times 2 will go to 0 and will not be encoded in the JPEG bitstream. The quantizer is the part of the JPEG baseline sequential encoder that causes the encoder to be a lossy one.

Entropy Coding

Once a block of data has been quantized, it enters an entropy coder, which creates the actual JPEG bitstream. The entropy coder first looks at the values in the quantized block of data in the zigzag sequence shown in Figure 16-4. Using this sequence ensures that the encoder will encounter all nonzero values in the block as early as possible.

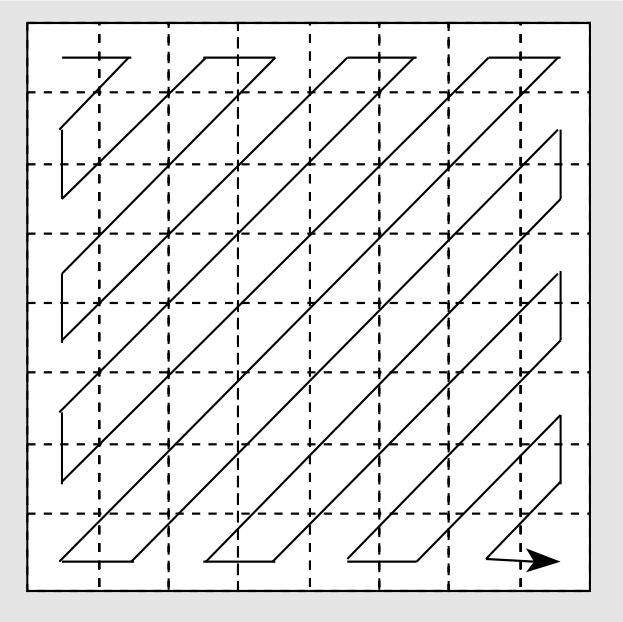

Figure 16-4 Zigzag Sequencing in JPEG Encoder

As the entropy encoder moves through the values in this order, it records three pieces of information each time it encounters a nonzero value: the number of 0's it passed over before finding the nonzero value, the number of bits it will take to encode the nonzero value, and the value itself. The first two pieces of information are considered a pair. For example, if the encoder skips over 7 zeros and then finds a 3, the pair will be 7/2 (2 is number of bits required to encode the value 3). The encoder then consults a Huffman table to find the bit sequence that represents the pair 7/2 and writes this bit sequence to the JPEG bitstream. It then encodes the value 3 using a variable-length code. The

encoder continues this process until all the remaining values in the block are 0's, at which point, it writes a special end-of-block bit sequence to the bitstream.

Creating a JPEG Baseline Sequential CIS

Before you can use the JPEG codec to compress images or decompress a JPEG bitstream, you must create a JPEG CIS. You do this by passing the compressor name `Jpeg` to the function `xil_cis_create()`. See the code fragment below.

```
XilCis cis;
XilSystemState state;

cis = xil_cis_create(state, "Jpeg");
```

JPEG Baseline Sequential Codec Attributes

As discussed in the section "General CIS Attributes" on page 257, there is a class of attributes that can be set for any CIS. There is also a set of attributes that are valid only for CISs attached to a JPEG baseline sequential codec. You set codec-specific attributes using the function `xil_cis_set_attribute()`, and you read them using the function `xil_cis_get_attribute()`.

The JPEG baseline sequential attributes can be broadly grouped into those that affect compression and those that affect decompression. The attributes are discussed under these headings below.

Compression Attributes

Setting any of the following attributes affects how the JPEG baseline sequential compressor compresses images.