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THE GREAT COMPRESSION

MPEG is the key behind many of today's high-capacity multimedia technologies. Here's an overview of what it is and how it works.

Most readers of this magazine have likely heard the term "MPEG," and are aware that it is the key technology that has made digital direct-to-home satellite TV, DVD video, DTV (digital TV), and other advances possible. In this article, we will explore what MPEG is, what it does, and some of the history behind it.

Why MPEG? MPEG, which stands for *M*oving *P*icture Coding *E*xperts *G*roup, is a technology for compressing the amount of data contained in moving images such as in film and video. It is also the name of the organization that has worked to create international standards for this technology.

But why is compression needed at all? Take a look at Fig. 1, which is a comparison of the volume of data required for a person to spend an hour enjoying various media forms. As you can see from that figure, an hour of music requires 1,000 times as much data space as an hour's worth of text, and an hour of video takes up 1 million times as much data as an hour of text. While high-capacity CDs (compact discs), MO (magnet optical) discs, or DVD (digital video discs) can hold more than previously available technologies, there is still a limit on how much data can be placed on a single disc.

In the broadcasting realm, digital technology coupled with compression would allow a high-definition TV (HDTV) signal to be broadcast using no more spectrum than a standard, analog signal. It would also allow the transmission of multiple channels of standard-definition digital TV in the same spectrum space as a single channel of analog Television.

How Compression Works. Technology for the perfect reproduction of moving images has yet to be developed. Television broadcasts and film footage use a series of still photographs to reproduce motion. For television, 30-frames-per-second are used, while 24-frames-per-second are used for film. (Japan and the United States use the same number of shots per second for television, while European countries use only 25 shots per second. Consequently, video tapes recorded in Europe cannot be viewed in Japan or the U.S. without special equipment. No such regional differences exist in relation to movies.)

When many photographs are continually transmitted like this, often there are only minute differences between one still image and the next. If there is absolutely no movement on the screen during the 1/30th or 1/24th of a second between images, there is no need to send the next photograph as long as the previous image has been stored and can be re-shown in the place of the next photo. In this way, the number of photographs sent (the volume of data) can be reduced.

Figure 2 shows two images of a moving airplane. The entire image other than the moving plane does not change from one image to the next. Thus, that part of the image that has not changed need not be retransmitted. Assuming the moving

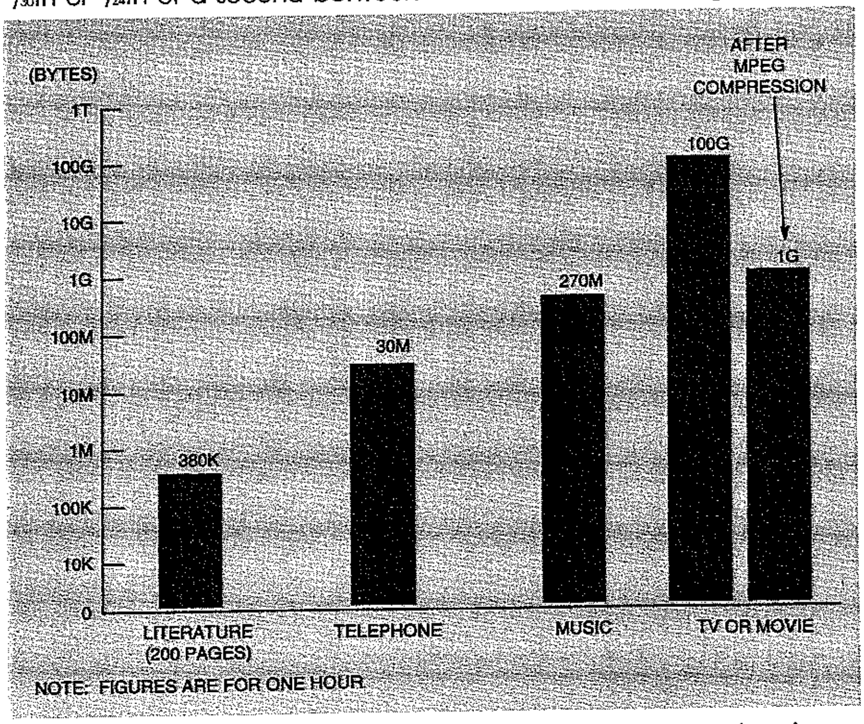

Fig. 1. While moving images (either video or film) require much more storage space than other types of media, MPEG compression can greatly reduce those requirements.

*Courtesy LOOK JAPAN, August 1997

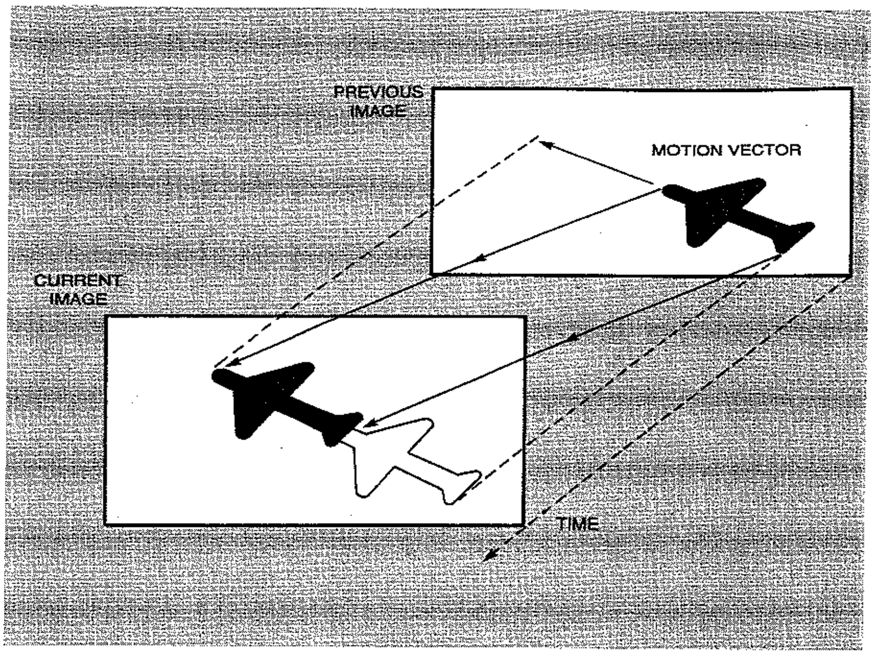

Fig. 2. For an object in motion, such as an airplane, and assuming that all other elements in the image are identical, the only additional information needed to produce the next frame is the object's motion vector and data for the area occupied by the object in the first frame.

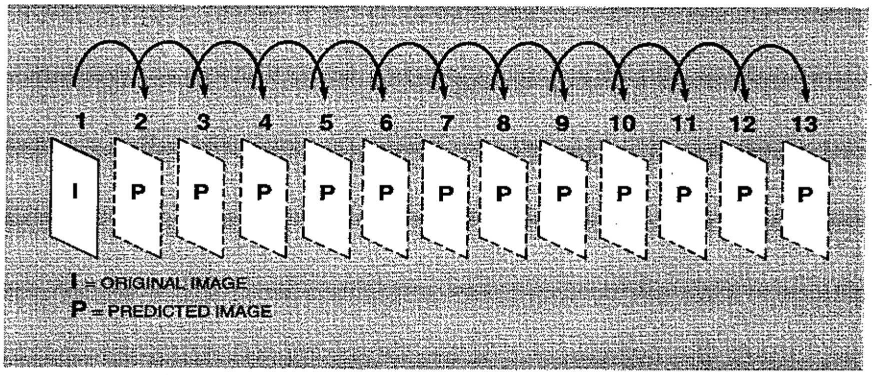

Fig. 3. In motion-compensated interframe coding, all images after the original (I) frame are predicted by combining the initial image and any motion information.

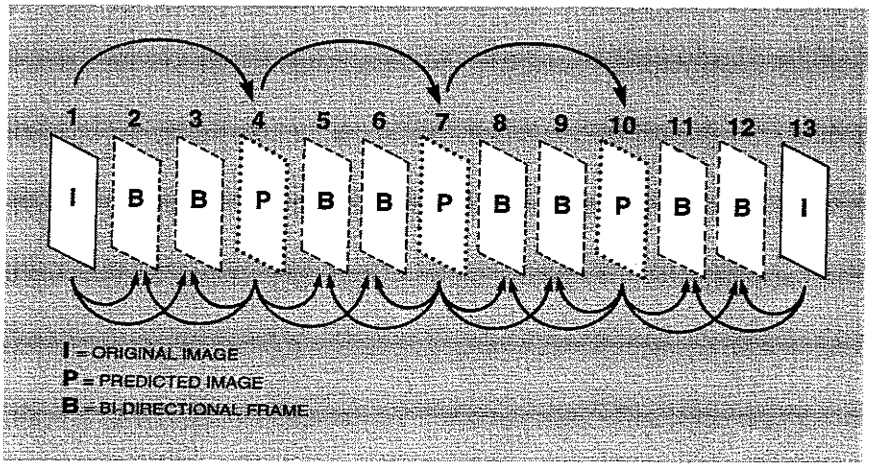

Fig. 4. In MPEG encoding, the frame stream is broken up into GOPs (group of pictures) and motion compensation from past and future images is used. For example, in this GOP the fifth frame is created using information from the fourth and seventh frames.

plane accounts for 1/20th of the total area of the image, for example, only 1/20th of the total volume of data need be transmitted to reproduce the next image. Furthermore, if the shape of the airplane is known, the only additional information needed is how far and in what direction (known as the vector of movement) the plane moved during the 1/30th of a second between the two still images.

In this way, the volume of data can be cut even more by simply moving the known image of the plane along the known vector of movement. (Of course, since it is not known what image will appear in the area occupied by the plane in the first image, the data for that area must be sent as well.) This method of reducing data volume combined with mathematical processing technology is called "motion-compensated interframe coding."

The initial research in that technology was initiated to find a way of making video telephone technology less expensive. MPEG took the motion-compensated-interframe-coding principle and corrected its faults, made it applicable to a wide range of fields, and standardized the technology so it could be used worldwide.

Establishing The Compression Standard. The history of MPEG standardization began in 1987 with the JPEG (Joint Photographic coding Experts Group). The difference between JPEG and MPEG is that JPEG encodes and compresses still images rather than moving images. By the fall of 1987, specifications for the JPEG international standards had already been settled and all that was left to do was to put them in writing and put them to a final international vote. Once those tasks were achieved, the organization formed to create the international standards would have completed their function. To dissolve the organization after going to all the trouble to create it, however, seemed a pity. In fact, there were calls for setting up a new task for the organization to take on. Then, at a meeting in the United States of JPEG members in November 1987, a discussion developed over the desire to place movies on CD and the possibility of creating compression-coding standards for film and television. Based

(Continued on page 56)

MULTICHANNEL TRIGGER

(continued from page 36)

arrangement for fitting the PC board into the enclosure given in the Parts List is shown in Fig. 3. Using a different case will probably need a different arrangement. The only requirement is that the switches and jacks be readily accessible.

Using the Multichannel Oscilloscope Trigger. To use the Multichannel Oscilloscope Trigger, locate a 5-volt source and ground connection on the circuit you will be testing. Attach the 5-volt source to pin 14 of J1, and connect pin 1 to ground. If you didn't permanently ground the enable input (pin 13), that pin should also be either grounded or connected to a signal that is low during the time that you want to trigger your oscilloscope.

As mentioned before, there are three ways to use the Multichannel Oscilloscope Trigger. The mode with the fastest speed is the eight-bit mode. Operation at speeds over 100 MHz is possible. To use that mode, set the qualifier and counter switch in S1 to the off position and set the S2 switches to the desired pattern of on and off states. The eight settings on S2 will be compared to the inputs on J1. A negative-going pulse will appear at J2 when a match is detected.

Probably the most common mode of operation will be the 10-bit mode. With that mode, you can typically decode a full byte of data on a computer's data bus during a read or write operation along with an enable signal. The 10-bit mode works the same as the eight-bit mode, except that it will only decode at rates up to 50 MHz. To use the 10-bit mode, the qualifier and counter switch in S1 must be on.

To use the Multichannel Oscilloscope Trigger in the counter mode, simply set the count switches as shown in Table 1. The counter mode lets the trigger output toggle on every second, third, or fourth occurrence of a match on the input pins.

If you want to use the trigger to qualify fewer than 8 or 10 inputs, simply set the S1 switches for the unused inputs to logic ones. The internal pull-up resistors on IC1 will automatically set the unused pins to the same state, making them valid. That will let the Multichannel Oscilloscope Trigger pulse its output based upon the other inputs.

To troubleshoot complex circuits, you might want to have several units available on your bench. Connecting the output of one device into the enable pin of another will let you see the state of some very complex signal combinations. Ω

TABLE 1

Count 1 (S1-b)	Count 2 (S1-a)	Trigger Function
OFF	OFF	Every occurrence
OFF	ON	Every second occurrence
ON	OFF	Every third occurence
ON	ON	Every fourth occurence

GREAT COMPRESSION

(continued from page 38)

on this discussion, the MPEG organization was formed in April 1988.

At the time, international compression-coding standards for video telephones were already being discussed. Initially, MPEG members believed that adopting those standards for film and television compression would be a simple matter, but their research turned up problems.

Figure 3 shows a moving image reproduced using the motion-compensated interframe-coding method already described. The P (predicted) images are generated one after another by incorporated data about the portion of image I (the original image) that has experienced motion. Although this is a very good method for compressing data, it has one fatal flaw. That flaw is that compression coding cannot start from a P image, but only from the original I image. (This can be compared to switching television channels in the middle of a broadcast: Without the original I image, the subsequent P images cannot be generated.) In addition, rewind playback, playing a video or film backwards, is also impossible. This shortcoming in the compression coding of television broadcasts has no place in the current video culture. Thus, MPEG's work began with the search for compression-coding standards under which channel-surfing, fast-forward playback, and rewind playback would be possible.

The eventual solution to this problem is shown in Fig. 4. As seen there, the series of still images are broken down into units of 12 to 15 photographs called a GOP (Group of Pictures). The initial image is always the original I image. As long as there is an I image, all the problems are resolved. However, an original image at the head of each GOP cuts into the degree of compression possible. To solve this problem, the degree of movement from one still image to the next is predicted using not only the previous image but future images as well. That is, the B (bi-directional) frame is an image created with motion compensation from past and future P frames or the I frame. The fifth B frame, for instance, was created with reference to the fourth and seventh P frames. This technique serves to both improve the accuracy of the predictions and cut back on amount of data required.

Faultless Timing. Despite its technological breakthroughs, MPEG would not have succeeded without the benefits of good luck and good timing. With the participation of many top scientists and researchers and under good, positive leadership, the standards were hammered out in a short period. Due to the swift movement, standardization coincided with the rise in popularity of the Internet and the standards were widely adopted.

MPEG is now firmly entrenched as the compression method of choice for a wide variety of audio/video technologies in the U.S., Japan, and throughout the world. In recognition of its technological achievements and its wide acceptance, particularly in the area of broadcast video, MPEG (including its predecessor, JPEG) were awarded an Emmy by the U.S. National Academy of Television Arts and Science in October 1996. Ω