CC/NUMBER 10
MARCH 8, 1982

This Week's Citation Classic

O'Neal J B, Jr. Predictive quantizing systems (differential pulse code modulation) for the transmission of television signals.
Bell Syst. Tech. J. 45:689-721, 1966.
[Bell Telephone Laboratories, Murray Hill, NJ]

Differential pulse code modulation (DPCM) is a technique used to encode analog signals into digital form suitable for transmission over digital channels. In DPCM, the difference between a signal sample and an estimate of this sample, based on its past, is quantized and transmitted. [The *SCI*® indicates that this paper has been cited over 110 times since 1966.]

J. Ben O'Neal, Jr.
Department of Electrical Engineering
North Carolina State University
Raleigh, NC 27650

January 21, 1982

"In 1966, many of us at Bell Telephone Laboratories thought that the time had finally arrived for videophone service. We were misquoting the famous statement of Victor Hugo, 'An invasion of armies can be resisted but not an idea whose time has come,' to describe the incipient communications revolution that was going to put Bell's PICTUREPHONE into every household. The success of PICTUREPHONE depended on using existing telephone cable pairs to transmit the video signal whose bandwidth was to be 375 kHz (this bandwidth was later extended to 1 MHz). This required encoding the video signal into a bit stream whose bit rate was as low as possible. It was work on this problem that produced the paper on DPCM.

"Bell Laboratories and the telecommunications industry as a whole were bathing in the unprecedented success of the T1 PCM carrier system used for speech. Encoding the PICTUREPHONE signal into PCM, however, resulted in a bit rate too large for cable pair. So we searched for more efficient ways of encoding video signals into digital form. DPCM was one of our candidates. As it turned out, DPCM, computer simulation, and data compression—not PICTUREPHONE—were ideas whose time had come. This paper was an amalgamation of these three ideas into an analysis of a digital encoding system for video signals.

"DPCM is an idea that was patented by C.C. Cutler in 1952.[1] That same year two important papers were published on this subject by B.N. Oliver[2] and C.W. Harrison,[3] who recognized that Weiner's theory of linear prediction was applicable to this encoder. All three of these men did their work at Bell Telephone Laboratories. The idea of DPCM, however, had remained dormant for about 14 years when I began to consider its application to PICTUREPHONE. In this intervening time period, the fabrication of transistors had reached the point where the signal processing functions required were economical. The paper was one of several[4] at the forefront of a renaissance in the application of practical data compression systems made economically possible by the transistor. Later, I was able to show that DPCM was a nearly optimum encoding procedure when the dimensionality of the signal could not be reduced.

"The paper's popularity stems in part from its tutorial nature, especially in the application of linear mean square prediction theory and computer simulation. Computer simulation of communication systems was in its infancy. I was schooled in this art by Jim Kaiser, who allowed me to question him continually until I understood the rudiments of digital filtering and simulation. Fortunately, I resisted the advice of a well-meaning reviewer to remove this trivial material which made the paper 'too long.'

"I could not have written this paper without the encouragement and insight of my able supervisor, T.V. Crater, and my department head, A.D. Hall. Recent progress in this field is documented in the tutorial article by J.D. Gibson."[5]

1. **Cutler C C.** *Differential quantization of communication signals.* US patent no. 2,605,361. 29 July 1952.
2. **Oliver B N.** Efficient coding. *Bell Syst. Tech. J.* 31:724-50, 1952.
3. **Harrison C W.** Experiments with linear prediction in television. *Bell Syst. Tech. J.* 31:764-83, 1952.
4. **McDonald R A.** Signal-to-noise and idle channel performance of differential pulse code modulation systems—particular applications to voice signals. *Bell Syst. Tech. J.* 45:1123-51, 1966.
5. **Gibson J D.** Adaptive prediction in speech differential encoding systems. *Proc. IEEE* 68:488-525, 1980.