THAM 15.1

HYBRID COMPRESSION OF VIDEO WITH GRAPHICS IN DTV COMMUNICATION SYSTEMS

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ABSTRACT

A new cost-effective and "near-lossless" quality compression system for images containing both video and graphics is presented. The scheme can be used successfully in two distinct architectures: for professional video distribution from content provider to broadcaster, and for local memory reduction in a consumer DTV receiver.

INTRODUCTION AND AIM

Teletext and On-Screen-Display (OSD) menus in TV systems [1] are leading to increasingly diverse TV images which mix video sequences with various types of graphical information. Simultaneously, Digital Video Broadcasting (DVB) based on MPEG-2 compression is being used in high-end DTV receivers. Unfortunately, the introduction of graphics data is only partially covered in these standards. For example, although the DVB standard allows additional data transmission in a separate channel, there are no facilities for an efficient compression of a joint graphics-video signal. Joint coding combines video and graphics into one signal, and would improve storage and/or transmission efficiency in the broadcasting chain. However, since MPEG-2 is optimized for normal moving video, its performance for graphics compression is dissatisfactory (e.g. edges of objects are not well preserved).

Our aim is to design a low-cost, high-quality compression algorithm for mixed video/graphics images. The proposed scheme could be used in two systems: for professional video communication from content provider to broadcaster, and local memory reduction in consumer DTV receivers. The previously mentioned systems have the following common properties: proprietary systems can be used for the compression of the video and graphics signals, and the image quality after decoding must be very high to avoid interference with MPEG-2 coding/decoding.

We evaluated *different* coding algorithms for graphics and video because their statistics and perception are considerably different. Figure 1 shows two system architectures for mixing the graphics into the video signal: at the receiver (Architecture 1) or content provider side (Architecture 2).

ARCHITECTURES AND EXPERIMENTS

Architecture 1. The major benefit of architecture 1 is that video and graphics can be compressed separately, using algorithms that optimally match the individual signal statistics and are tuned for good perception. For the lossless coding of graphics, two compression schemes have been designed: a novel algorithm based on contour coding, and a combined runlength-Huffman coding scheme. Both algorithms achieve compression factors of 10 to 15 for OSD/Close Caption type of images.

For memory reduction in DTV receivers, runlength coding should be used due to its simple implementation and good compression performance. To reduce the memory necessary for local storage of the video data within DTV receivers, a "near-lossless" Block Predictive Coding [3] has been adopted, which enables a limited compression factor of 2-3, while preserving "near-lossless" quality (SNR > 45 dB) and individual pixel access. Nevertheless, the scheme has very low complexity.

For the lossless graphics compression at the content provider side, a novel contour coding algorithm has been used. Its compression efficiency outperforms the runlength coding scheme by almost 20% and the added complexity is of minor importance for professional applications. The "near-lossless" Block Predictive Coding proposed for embedded memory compression in DTV receivers could also be successfully used for compressing the video data distributed by the content provider. Due to the high image quality of this coding system, no interference occurs with the MPEG-2 compression system used by the broadcasters elsewhere in the transmission chain. Moreover, this coding technique allows easy access to the individual pixels in the compressed domain for further editing or post-processing.

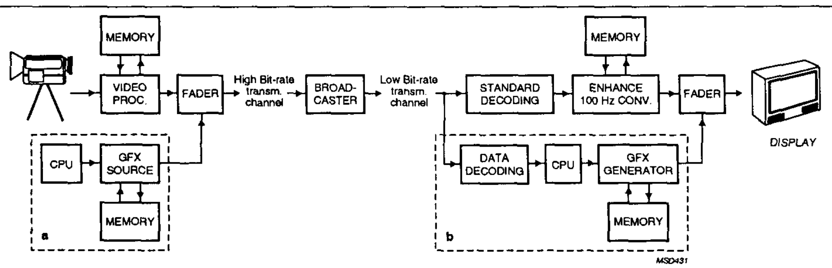

Fig.1 Block diagram of a complete TV communication chain with graphics inserted both/either by a) the content provider side (Architecture 2) and/or b) the TV receiver side (Architecture 1).

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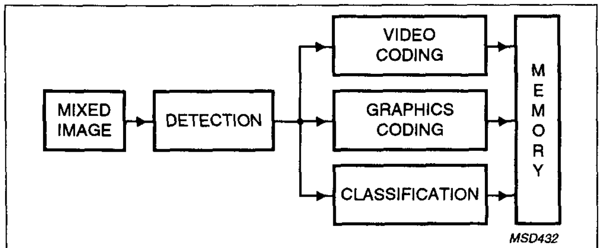

Fig.2 Detection and classification mechanism for high-quality coding of mixed video-graphics images.

Architecture 2. The second architecture, based on mixed transmission/storage, is cost-efficient: video segments overlapped by graphics data do not need to be transmitted and stored locally, thus saving memory at the receiver. However, mixed video/graphics data at the encoder is not desirable when using MPEG-2 for transmission, since it is not able to code the graphics data with high quality (already mentioned). Nevertheless, video and graphics signals may sometimes be mixed and transmitted or stored in the analog or uncompressed digital domain (e.g. in a DTV receiver's image post-processing IC where video and graphics need to be combined and stored in local memory). An *a-priori* graphics detection algorithm is then necessary prior to any local memory compression algorithm, in order to preserve a high image quality (see Fig.2). Our new low-cost detection algorithm uses the fact that graphics data is defined by sharp boundaries and relatively large areas with identical signal values (Fig.3). This algorithm has an accuracy above 90%. The embedded graphics detection could also enable appropriate video or graphics post-processing algorithms.

Table 1 Compression Factors of coding algorithms for video (CFV), detected graphics (CFG), "neighboring-area" graphics (CFNAG) and classification (CFC); RLC=run-length coding, HFM=Huffman coding, ARC=Arithmetic coding.

ALG.	CFV	CFG	CFNAG	CFC	CF TOTAL
RLC	2.10	3.81	1.29	1.65	2.22
HFM	2.27	4.02	1.47	1.81	2.41
ARC	2.45	4.87	1.48	1.81	2.70

The "near-lossless" Block Predictive Coding algorithm was used for video data, while three lossless compression algorithms were evaluated for graphics data: arithmetic, Huffman and runlength coding. Table 1 shows the results for the various video/graphics classes and the classification stream. A bit-rate controller ensures a fixed compression factor of 2-3, independent of image statistics (e.g. video/graphics percentage). However, due to the relatively modest compression gain, this architecture is only efficient for local memory reduction in DTV receivers. Also, the detection and graphics compression algorithms are not needed if the mixed video/graphics signal was already degraded by a low-quality transmission link. In such a case, the local memory of a DTV receiver could be reduced by employing the embedded coding algorithms in [2] or [3] for both video and graphics.

CONCLUSIONS

Based on the in-depth study of the previous two architectures, it can be concluded that separate transmission of graphics and video signals (Architecture 1) is most efficient for transmitting mixed signal images between content provider and broadcaster. Independent coding of video and graphics gives a higher overall compression factor, mainly determined by the quality and complexity of the video compression system. An additional benefit is that new graphics can be added to the already mixed image at the receiver side (e.g. menus), such that video and graphics can be mixed at two levels. This architecture also allows broadcasters to use established standards like MPEG-2 for the video signal, while the graphics data (not compressed by MPEG-2 in high-quality) can be transmitted in a different compression format to the DTV receiver.

Architecture 2 is better for local storage of mixed images at the receiver because of its cost-effective memory use. In this case, simple coding algorithms can be employed to reduce the memory costs of the receiver. A compression factor of 2-3 gives an attractive reduction of receiver memory, and the picture quality clearly surpasses that of established compression standards for transmission (e.g. MPEG-2), thus avoiding propagation of coding artifacts from the embedded coding system [2].

REFERENCES

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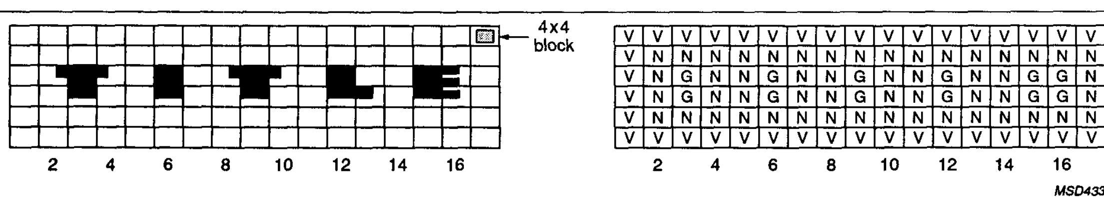

Fig.3 Division of the frame into video (V), graphics (G) and neighboring-area blocks (N).