Video Compression for Underwater Applications

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ABSTRACT

Low bit rate video compression is considered in this work. The main objective is to transmit real time video sequences, acquired in underwater environments, through the underwater acoustic channel. This is a very demanding problem given the strong limitations imposed by the physical properties of that channel. In particular, efficient and reliable data communication underwater acoustic systems can only accommodate low transmission rates. The goal is therefore to design specific video compression algorithms compatible with real time transmission at data rates upper bounded in the range 20-30 Kbps.

This problem was motivated by a practical application: remote visual sensing of hydrothermal activity on the ocean bottom. The final users are scientists interested in geological and biological phenomena related with that activity, which can be detected by observing the emission of bubbles of gas and their ascending movement in the direction of the ocean surface. These emissions produce video images with very specific properties: low contrast, high transparency, and relatively high velocity of the ascending movement of the bubbles. These properties preclude direct use of standard low bit rate video compression techniques.

Here, a new compression method is proposed, developed, and evaluated. Essentially, it runs in two steps: **(i)** detection of the ascending bubble columns and segmentation of the images by isolating those blocks where strict ascending movement is present; and **(ii)** compression of this class of image blocks.

The first step is implemented using space/time Gabor filters. This approach results in a low complexity, parallel and efficient segmentation algorithm.

The second step, compression of the selected image blocks, is based on vector quantization techniques. The main novelty is that we use a new vector quantization method that allows the compression of a time sequence of image blocks using just one entry of the codebook, resulting in what can be denoted as a 3D compression algorithm.

The experiments performed using real video sequences show that the algorithms developed cope with the specified data rate constraints. The quality of the reconstructed video sequences was quantitatively evaluated using the PSNR measure. As a consequence of the high compression rates given by the proposed methods, the results obtained show acceptable values of the PSNR. Also, the qualitative visual quality of the reconstructed images is perfectly compatible with the final user requirements: identifiable background, bubble emission visibility, and assessment to bubbles' dimensions and velocity.

Keywords: Video Compression, Vector Quantization, Gabor Filters, Acoustic Transmission, Underwater Vehicle.