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Object–Oriented Analysis–Synthesis Coding Using Prototype Prediction for Colour Update

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Abstract

In an object–oriented analysis–synthesis coder [1], based on the source model of flexible 2D–objects with 2D–motion, each image of a sequence is subdivided into arbitrarily shaped objects. The objects are described by three parameter sets defining their motion, shape and colour, where the colour parameters denote the luminance and chrominance values of the object surface. Two classes of objects are distinguished: for the objects of model compliance (*MC–Objects*), the motion description by the source model is sufficiently exact and only shape and motion parameters have to be transmitted; for the objects of model failure (*MF–Objects*), the motion description by the source model fails and colour parameters have to be transmitted instead of the motion parameters. In order to increase the efficiency of the coder, a new predictive technique for the coding of colour parameters is presented using image pattern prototypes for prediction. The prototypes are extracted from previously coded images, identically stored at the coder and the decoder, and thus can be used for the prediction of the colour parameters of an object currently to be coded, applying a suitably defined mapping function. The prediction error is coded by an adaptive combination of DCT and Intraframe DPCM [2]. For the reconstruction of the object at the decoder the address of the image pattern prototype and the calculated mapping parameters have to be transmitted as side information. Prototype prediction is only applied, when its data rate favorably compares with a special motion compensating hybrid scheme; this control strategy guarantees an increase in coder efficiency.

1. Colour Coding by Prototype Prediction

At the beginning of an image transmission there are no image pattern prototypes (*IPPs*) at the coder and the decoder, and the colour parameters are coded using a motion compensating hybrid scheme. As soon as images are transmitted, IPPs can be extracted from the coded image and stored in a memory. From then on, colour parameters of MF–Objects can be coded either applying prototype prediction or motion compensating prediction. The decision which scheme to use depends on the needed data rate and is performed for each MF–Object by coder selection. For both schemes the prediction error is coded using an adaptive combination of DCT and Intraframe DPCM. When the maximum size of the IPP memory is reached, further prototypes can either be rejected or they can be exchanged for stored prototypes. Thus it is possible to adapt the memory to slow variations of image content by exchanging old, unsuitable IPPs for new ones. Applying the same prototype update strategy at the coder and the decoder, this can be done without additional transmission of information.

2. Extraction and Application of Image Pattern Prototypes

The image pattern prototypes are extracted from the coded images, especially from the current MF–Objects. Because the MF–Objects have an arbitrary shape, a special algorithm is applied extracting as one image pattern prototype a rectangular image region containing the whole MF–Object or only parts of it. The size of the IPP rectangle has a large influence on the quality of the prediction. It has not yet been optimized, but first simulations have shown that for CIF (Common Intermediate Format: 288 lines, 352 pel/line) the side lengths should be in the range of 30 to 80 picture elements.

In order to find the optimal IPP for the prediction of the colour parameters of an MF–Object, as a rule the prediction has to be performed using all available prototypes. Instead of this full search strategy it is possible to reduce the number of prototypes to be checked by classifying them. Applying an appropriate classification characteristic, only those IPPs with a characteristic similar to that of the MF–Object are accepted as suitable for the prediction. Only for these prototypes, denoted as *candidates*, a prediction has to be performed. For the prediction of the colour parameters, the MF–Object O_{MF} is mapped to all candidates, applying a suitable mapping function T. The parameters of the mapping function, the *mapping parameters*, are optimized for each candidate, applying the mean square error $MSE[C_i\ ,T\ (O_{MF})]$ between the candidate C_i and the mapped MF–Object $T(O_{MF})$ as quality criterion. The candidate which leads to the minimum mean square error is used for the prediction taking into account the calculated optimal mapping parameters. The residual prediction error is coded and sent along with the coded side information to the receiver.

3. Experimental results

First simulation results (Table 1) have been obtained using the test sequence *Miss America* in CIF with a memory of 128 image pattern prototypes. As a basic form of mapping, a displacement was used with one pel spatial resolution and a range of ± 8 pel. The side information was PCM coded and for the coding of the prediction error an adaptive combination of DCT and Intraframe DPCM was used. Simulations have been done under constraint of three different image qualities (34dB, 36dB and 38dB), where the image quality denotes the SNR measured in the image area of the MF–Objects; the simulation at 36dB corresponds to a data rate at about 64 kBit/s. The results are compared to the data rate needed using only the motion compensating hybrid scheme.

	Coding colour parameters of MF–Objects using prototype prediction		
SNR [dB]	34 dB	36 dB	38 dB
Absolute data rate in Bit/Pel	1.07	1.58	2.16
Relative gain in percent	4 %	5 %	6 %
Percentage of MF–Objects where prototype prediction has been applied	25 %	30 %	40 %

Table 1: Simulation results applying prototype prediction for colour parameter coding compared to the data rate needed using only the motion compensating hybrid scheme

4. Conclusions

A new technique for coding of colour parameters in an object–oriented analysis–synthesis coder using image pattern prototypes for prediction has been presented. Applying a displacement as a first basic mapping for prediction and a memory of 128 prototypes the efficiency of the colour coding was increased about 5%, compared to a special motion compensating hybrid scheme. Furthermore, using this technique it is possible to adapt the colour coding to slow variations of image content without additional side information, an important feature with respect to luminance or contrast changes as they appear in real life scenes. The adaptive component has not been implemented yet and is still under study. Further research will deal with more sophisticated mapping functions to improve the prediction, with a more efficient coding of side information using entropy coding techniques and with an optimization of shape, size and number of prototypes used for prediction.

References:

[1] M. Hötter, ”Object–Oriented Analysis–Synthesis Coding of moving Two–Dimensional Objects”, *Image Communication*, Vol. 2, No. 4, December 1990, pp. 409–428.

[2] H. Schiller, M. Hötter, ”Investigations on Colour Coding in an Object Oriented Analysis–Synthesis Coder”, submitted for publication in *Signal Processing: Image Communication.*