Applications of digital systems: effective error-free image transmission

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1. Introduction

Digital systems are present in our everyday life. Main area of application digital techniques is communication of various forms. Along with the popularity of application of such systems, there arise problems of the data quality. A special place in this class of data transmission belongs to image processing. Main reason for this is ability of compression, i.e. presentation the same data with reduced number of information bits. Unfortunately, the data compressed are prone to even small number of transmission errors.

2. Digital image processing

Typical scheme of digital transmission of image consists of five elements: decorrelation of the data (by one of transforms, e.g.: DCT, FFT, DWT) and quantization, compression, preparation for transmission, including error resilient coding and modulation, transmission, usually affected by errors, demodulation and decoding, decompression, inverse quantization and inverse transformation. As in such a scheme the transmission errors can affect severily the transmitted data, there are used techniques to protect data.

3. Protection of the transmitted data

There exists many techniques of protection the transmitted signal. The data affected by errors can be retransmitted, error correcting codes can be applied or the special error resilient coding can be used to restore missing data. All these techniques are designed to obtain the result at cost of adding supplementary information to the transmitted signal. Unfortunately, this operation decreases compression ratio, or even requires a feedback channel. In many cases the feedback cannot be applied, e.g. in the real-time transmission systems. In many others applications the additional data are not allowed. What's more, some of these techniques can not be used by definition, e.g. retransmission of the data in case of compression for storage purposes - when the error is detected, there is no possibility to access the source data.

4. Error concealment

Error concealment operation consists in acceptation of the occurrence of channel errors and processing the image with aim of improving its quality at the receiver only. The techniques can be added to existing coding standards, since there is no need to introduce any changes of encoder circuits and the whole operation is performed by the decoder. In many cases special algorithms are designed to replace existing decoding algorithms with new and better method, with preservation of the data compatibility.

Existing algorithms use different methods to detect and correct errors. None of them, however, use a spatial domain error pattern detection, which can significantly improve the algorithm’s error detection performance. They are dedicated for particular class of applications. The error concealment algorithm proposed in this work has been designed as a flexible tool, to suit particular application.

5. Hybrid Error Concealment Technique

The Hybrid Error Concealment algorithm complies the best features of the both possibilities for detection and correction of errors, which are: image analysis and image spectrum analysis. The algorithm comprises five stages:

1) input filtering that eliminates errors affecting the high-frequency data and reduces amount of data to be processed;

2) error pattern detection (spatial domain operation); it examines the image blocks locating distinguishable error patterns and marks error locations in a matrix called the error map,

3) detecting abnormal values of DCT coefficients (frequency domain); at this stage the values of the coefficients are compared with the mean value of corresponding coefficients in adjacent blocks,

4) actual correction of the DCT-coded image (DCT coefficients) using the error map; the attempt is to reconstruct value of the affected coefficients by computing the average of corresponding coefficients in adjacent blocks,

5) output smoothing image filtering to eliminate the high discontinuities in luminance.

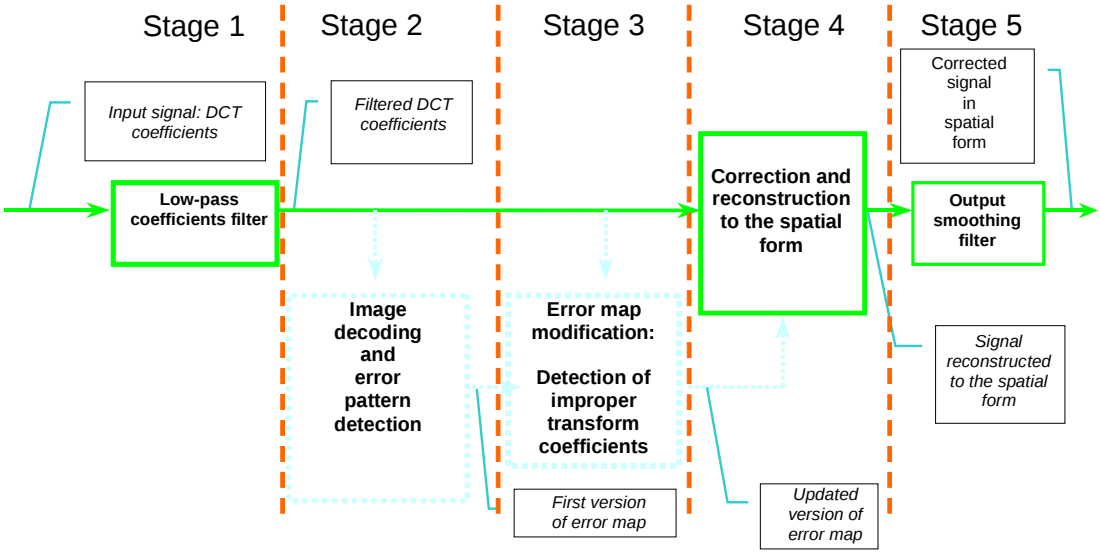

Fig. 1. Hybrid Error Concealment Algorithm Scheme

6. Results

The algorithm proved to be more efficient that existing ones. Depending on the image distortion, its efficiency is 0.5 to 2% of DB (measured by PSNR) better. Fig. 1. shows results of operation of two other algorithms with the presented one, for benchmark image Claire, with simulated transmission errors of 3%.

a) b) c) d)

Benchmark image transmitted with Bit Error Rate BER=3%
a) no correction, PSNR=8.23 dB
b) image-domain correction only, PSNR=11.6 dB
c) spectrum-domain correction only, PSNR=22.79 dB
d) Hybrid Error Concealment Algorithm, PSNR=24.5 dB

The algorithm can be effectively implemented in dedicated logic structure, which is a subject of current research.